WEST VIRGINIA
GEOLOGICAL SURVEY

STATE OF WEST VIRGINIA
JUNE 20 1863
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Tri State Oil & Gas Co., of W. Va.
Box 827 Parkersburg, W. Va.

WEST VIRGINIA

GEOLOGICAL SURVEY

COUNTY REPORTS AND MAPS

Ohio, Brooke and Hancock Counties

BY

G. P. GRIMSLEY, Assistant State Geologist

I. C. WHITE, State Geologist

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LEICESTER PATTON - - - - - *Assistant Chemist.*

R. C. TUCKER - - - - - *Chief Clerk and Stenographer.*

LETTER OF TRANSMITTAL.

To His Excellency, Wm. M. O. Dawson, Governor of West Virginia, and President of the Geological Survey Commission:

SIR:—I have the honor to transmit herewith the Detailed Geological Report of Professor George P. Grimsley upon the counties of Ohio, Brooke, and Hancock, as well as the accompanying geologic maps and charts showing the distribution of important coals, clays, and limestone beds. The volume has been delayed two months or more awaiting the completion of an important test boring made by the Wheeling Board of Trade at Glenova, four miles above Wheeling, as a test for the Allegheny series of coals, the geologic horizon of which is several hundred feet below the Ohio river.

Very respectfully,

I. C. WHITE,

State Geologist.

Morgantown, W. Va., April 15, 1907.

INTRODUCTION.

By I. C. White.

The bill establishing the Geologic and Economic Survey of West Virginia was enacted during the legislative session of 1897. When the present State Geologist had been appointed to that office and had formally accepted the superintendency of the Survey in December, 1897, he submitted a plan which the Commission (consisting of Hon. Geo. W. Atkinson, Hon. M. A. Kendall, Dr. Jerome Hall Raymond, Hon. James H. Stewart, and S. W. Atkinson) accepted as a basis for future work. This plan involved, first, the publication of a series of volumes or reports dealing with the State's principal mineral resources, each covering in a general way the entire state. Second, the preparation and publication from time to time of general maps of the state's area illustrating the distribution of its mineral resources. Third, since no accurate maps of any portion of the state were in existence, and about one-third of its counties had no maps whatever, it was urged that as a basis for future geologic work, the state should enter into co-operation with the U. S. Geological Survey as other surrounding states like Maryland, and Pennsylvania were doing, in the preparation of an accurate topographic map of the State's entire area on a scale of one mile to the inch, each party to bear one-half of the cost of the preparation of such maps, and the U. S. Geological Survey all the cost of engraving, these engravings to be accessible to the State through transfers furnished free to the State. Fourth, on the completion and publication of topographic maps of the counties related to each other geographically and geologically, county reports covering in one volume two or more counties were to be prepared, in which not only the mineral wealth, but the soils, timber, water power, topography, climate, history, etc., should be described in detail, accompanied by an atlas of topographic, geologic, and economic maps of each county, the aim

being to give all the people of the state a full supply of accurate maps of their respective counties, and detailed information concerning their minerals and other natural resources.

At the session of 1901, the State Legislature adopted the proposed plan of co-operative map work and has since that time appropriated $15,000 annually for such co-operation. With these sums supplemented by an equal amount ($90,000) from the National Treasury, over 9,000 square miles of the state's area (24,780) have now been covered by very accurate topographic surveys and maps. These surveys cover the entire areas of Hancock, Brooke, Ohio, Marshall, Wetzel, Tyler, Marion, Monongalia, Preston, Taylor, Barbour, Lewis, Harrison, Doddridge, Pleasants, Ritchie, Wood, Wirt, Calhoun, Roane, Jackson, and Mason, together with portions of Randolph, Braxton, Gilmer, Clay, Kanawha, Putnam, Cabell, and Wayne; also portions of Tucker, Mineral, Morgan, and Berkeley. In the meantime, four reports or volumes of a general nature have been published, together with one Bulletin. Two others are under preparation. The entire list is as follows:

March 20, 1899, Volume I, Petroleum and Natural Gas.
July 20, 1901, Bulletin No. 1, Bibliography and Cartography.
June 15, 1903, Volume II, Coal.
July 1, 1904, Volume I-(a), Petroleum and Natural Gas.
March 1, 1906, Volume III, Clays, Cements and Limestones.
In preparation Volume IV, Ores, Building Stones, etc.
In preparation Volume II-(a), Coal.
December, 1898, Coal, Oil and Gas Map.
January 1, 1904, New Coal, Oil and Gas Map.
October 1, 1905, Railroad Map.

The first of the several counties to be entirely mapped were Ohio, Brooke, and Hancock, and hence on the completion of Volume III by Professor Grimsley in 1905, the work of preparing a detailed report on these three counties was assigned to him. The volume herewith presented to the public, and especially to the citizens of these counties, is the result of his labors. That it will prove of great practical value to all the people residing withing the area described cannot be questioned.

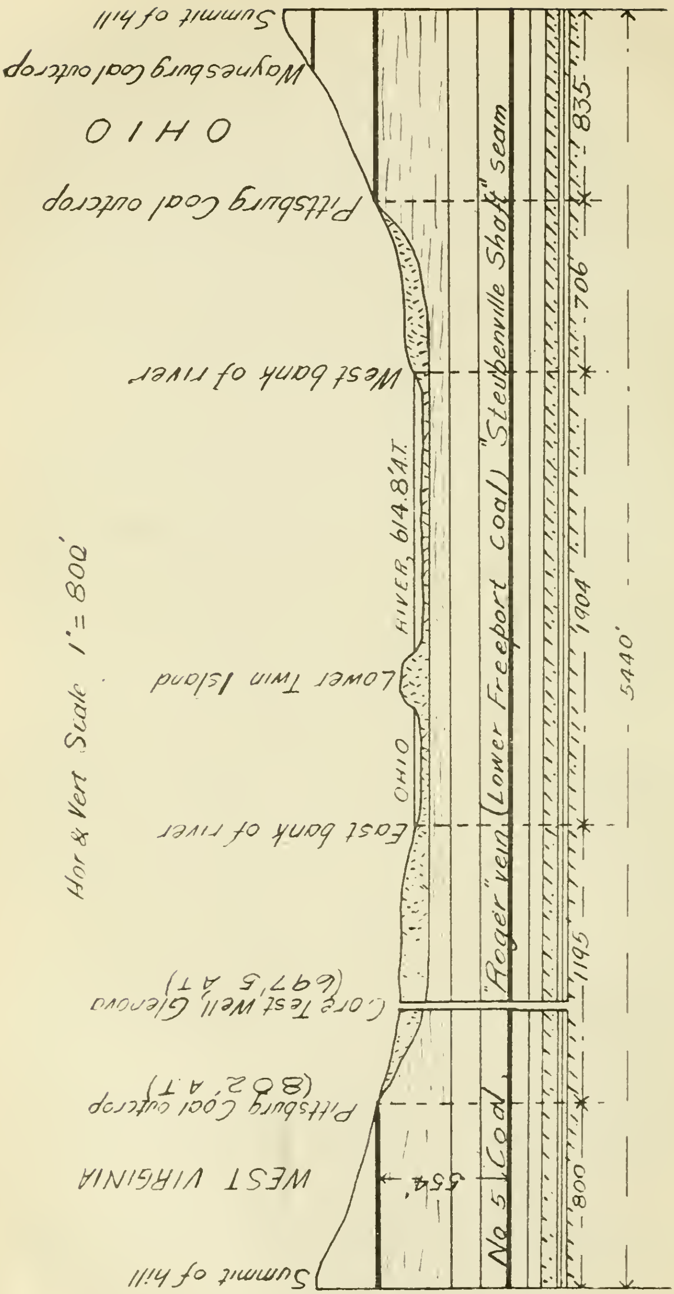
The County Commissioners and other officers of each county will find in the accurate topographic maps the best possible guides

for locating bridges, laying out new roads, and improving old ones so as to secure the shortest routes and best grades between important points. The accompanying geologic maps will also furnish the county officers a reliable basis for estimating the mineral and real estate values in the different sections. While to those interested in coal, limestone, clays, shales, etc., the report with its numerous sections, analyses, cuts and maps, will prove invaluable. To the farmer and horticulturist, the accompanying soil maps will prove an additional element of value, made as they have been by the experts of the National Bureau of Soils. The topographic maps will also prove of great benefit to the agricultural interests in giving at a glance accurate elevations above sea level, and thus indicating the proper zones for the successful growth of certain fruits, cereals, and other agricultural products. To the engineer who would plan railroads, trolley lines, water supplies, sewage disposal, location of factories, opening of mines, or who would study any other problems with which the modern engineer is confronted, these maps and reports must prove of the greatest benefit. In fact, there is not one single interest of the citizens of the state, and of the several counties especially, that will not be greatly promoted by the publication of these detailed reports.

The value set upon these reports is illustrated by the action of the Wheeling Board of Trade in raising $2,500 by subscription with which to put down a boring on its own lands at Glenova, four miles north from Wheeling, in order to determine the presence or absence of workable coal in the Allegheny series, and have the same described in this report.

As is well known, the coal beds which rise to the surface in Hancock county and crop along the hills at New Cumberland and Chester, dip rapidly under the Ohio river below the mouth of Kings creek, so that at Steubenville the "Roger," "No. V," or Lower Freeport coal bed is about 100 feet below water level, and the dip continuing, it is about 180 feet below the same at Wellsburg, and 368 feet at Glenova. While at the mouth of Wheeling creek the depth is probably 450 feet below the bed of the Ohio river.

The accompanying cross section of the Ohio river valley, showing the width and depth of the same at Glenova, is based



Cross-Section of the Ohio River Valley at Glenova, Showing Outcropping and Underground Strata.

upon surveys executed by Mr. C. C. Smith, civil engineer, of Wheeling, W. Va., under the direction of the Wheeling Board of Trade. The amount of filling shown under the bed of the river is based upon the results found at Dam No. 11, just below Wellsburg, and at other points along the Ohio river between Wheeling and Parkersburg, in which never more than an average of 30 to 35 feet of filling has been found in the bed of the Ohio below water level. The sketch was reduced for publication by Mr. Ray V. Hennen, Assistant Geologist of the Survey, from the large scale drawing of Mr. Smith, to which was added the underlying rock formations as developed by the drill.

The test hole was sunk by the Christman Company of Massilon, Ohio, the immediate supervision of the drilling being committed to Mr. J. C. McKinley, the coal and coke operator of Wheeling, W. Va., to whose active and intelligent interest in the work, in co-operation with Mr. R. B. Naylor, the very efficient secretary of the Wheeling Board of Trade, the Survey is indebted for the accompanying detailed log of the well.

The southward dip of all the strata is indicated by the elevations of the Pittsburg coal as given in Mr. Grimsley's report, beginning at its northern outcrop; namely:

Truax mine, south of Osburn's Mills	1200 A. T.
One mile northeast of Holliday's Cove	1153
Mentor mine, near Wheeling Junction	1120
McKim mine, east of Fairy Glen	1074
Cram mine, near Wellsburg	993
Glenova	802
Wheeling	700

The above table of elevations of the Pittsburg coal gives at Glenova an interval of 802—618=184 feet for the elevation of that seam above low water in the Ohio, or 104½ feet above the level of the bore hole as determined by Mr. Smith. Prof. Grimsley's Wellsburg section gives an interval of 557 feet between the Pittsburg coal and the "Steubenville shaft" seam or Lower Freeport coal at Wellsburg, fourteen miles above Glenova, while the record of the Central Glass Company's boring in Wheeling gave 556 feet for this same interval as determined by the writer, so that, based upon these figures, the Lower Freeport coal was due to be found in the Glenova boring at a depth of 556½—104½= 452 feet, or say 368 feet below low water. The record of the

Glenova boring shows that the Lower Freeport coal was actually found at a depth of 449 feet 3 inches, or within three feet of where it was expected on the basis of the Wellsburg and Wheeling records.

Samples of the core brought up by the drill were carefully preserved by the contractor, and from them the writer, aided by Mr. J. C. McKinley, has compiled the following record of the strata penetrated:

Well mouth above tide..................................672′ 2″

	Thickness.		Depth.		Below Pittsburg Coal.	
1. Clay, dark yellowish, plastic	6′	4″	6′	4″	110′	10″
2. Sand, coarse, brownish-gray, with pebbles of quartz, silex, and other hard materials, nothing larger than ¼″ by ½″ in size...	43′	8″	50′	0″	154′	6″
3. Sand, brownish gray, finer, no pebbles..............	12′	0″	62′	0″	166′	6″
4. Sand, coarse, brown, much oxidized, few pebbles....	6′	0″	68′	0″	172′	6″
5. Sand, fine, yellowish-brown no pebbles..............	19′	0″	87′	0″	191′	6″
6. Sand, dark gray, coarse, mixed with clay at bottom	6′	0″	93′	0″	197′	6″
7. Bed rock, bluish-gray, fine grained sandstone.......	0′	6″	93′	6″	198′	0″
8. Limestone, Ames, with fossil Crinoids and Productus Nebrascensis	0′	3″	93′	9″	198′	0″
9. Clays and shales, much red and variegated (Pittsburg red shale)..............	18′	6″	112′	3″	216′	9″
10. Shales, sandy, gray........	6′	9″	119′	0″	223′	6″
11. Fire clay, sandy...........	1′	0″	120′	0″	224′	6″
12. Shales, greenish-gray, sandy	4′	3″	124′	3″	228′	9″
13. Shales, red and variegated (base of Pittsburg red shale)	16′	6″	140′	9″	245′	3″
14. Sandy shales interstratified with micaceous, shaly sandstones	57′	6″	198′	3″	302′	9″
15. Shales, dark, sandy with fossil plant fragments.	1′	9″	200′	0″	304′	6″
16. Shales, sandy, dark gray..	6′	6″	206′	6″	311′	0″
17. Shales, dark, fossil shells, crinoids, etc.............	1′	6″	208′	0″	312′	6″
18. Limestone, impure fossiliferous	0′	10″	208′	10″	313′	4″
19. Shale, dark, sandy........	2′	0″	210′	10″	315′	4″
20. Coal, Bakerstown (Barton).	0′	8″	211′	6″	316′	0″

		Thickness.		Depth.		Below Pittsburg Coal.	
21.	Fire clay, sandy, impure, variegated at base.......	4′	0″	215′	6″	320′	0″
22.	Shales, red and variegated.	10′	2″	225′	8″	330′	2″
23.	Shales, limy, very fossiliferous Chonetes granulifera C. mesoloba., Productus Nebrascensis, P. semireticulatus Fenestella, etc	2′	8″	228′	4″	332′	10″
24.	Limestone, Cambridge, fossil crinoids, etc.........	0′	4″	228′	8″	333′	2″
25.	Fire clay, impure, sandy...	6′	4″	235′	0″	339′	6″
26.	Shales, light gray, sandy...	40′	4″	275′	4″	379′	10″
27.	Shales, dark gray, fossiliferous Aviculopecten numerous	11′	10″	287′	2″	391′	8″
28.	Shales, light gray, sandy...	27′	0″	314′	2″	418′	8″
29.	Limy, fossiliferous shale, dark (Brush creek limestone)	1′	4″	315′	6″	420′	0″
30.	Shales, sandy, micaceous, gray	4′	6″	320′	0″	424′	6″
31.	Shales, dark gray, fossiliferous, many Aviculopectens	11′	0″	331′	0″	435′	6″
32.	Bituminous slate..........	1′	4″	332′	4″	436′	10″
33.	Coal, Brush Creek, hard, semi-cannel	0′	6″	332′	10″	437′	4″
34.	Fire clay, impure, sandy...	2′	2″	335′	0″	439′	6″
35.	Fire clay, limy............	5′	0″	340′	0″	444′	6″
36.	Fire clay, stained red with iron	3′	10″	343′	10″	448′	4″
37.	Shale, gray, sandy with streaks of impure fire clay	19′	11″	363′	9″	468′	3″
38.	Limestone, gray...........	1′	9″	365′	6″	470′	0″
39.	Fire clay, limy and sandy..	2′	11″	368′	5″	472′	11″
40.	Limestone, gray...........	2′	0″	370′	5″	474′	11″
41.	Shale, sandy, and impure fire clay................	2′	7″	373′	0″	477′	6″
42.	Limestone, gray, minute fossils (fresh water).......	4′	0″	377′	0″	481′	6″
43.	Fire clay (Bolivar?) limy, and sandy, stained reddish in middle for 3 feet.	13′	0″	390′	0″	494′	6″
44.	Shale, gray, sandy.........	5′	0″	395′	0″	499′	6″
45.	Sandstone, gray, micaceous	6′	6″	401′	6″	506′	0″
46.	Shale, gray, sandy........	5′	0″	406′	6″	511′	0″
47.	Fire clay..................	4′	0″	410′	6″	515′	0″
48.	Shale, sandy, light gray...	5′	0″	415′	6″	520′	0″
49.	Sandstone, micaceous, laminated	7′	4″	422′	10″	527′	4″
50.	Shale, sandy, gray interlaminated with layers of micaceous sandstone, slight flow of gas in this interval	10′	11″	433′	9″	538′	3″

		Thickness.		Depth.		Below Pittsburg Coal.	
51.	Bituminous slate, fossil fish scales	0′	9″	434′	6″	539′	0″
52.	Shale, sandy, or impure fire clay	1′	8″	436′	2″	540′	8″
53.	Shale, limy, dark	1′	2″	437′	4″	541′	10″
54.	Limestone, light gray, rather pure	2′	8″	440′	0″	544′	6″
55.	Limestone and clay	5′	0″	445′	0″	549′	6″
56.	Clay and shales	3′	6″	448′	6″	553′	0″
57.	Shales, dark	0′	9″	449′	3″	553′	9″
58.	Coal, **Lower Freeport, "Steubenville shaft seam," "Roger vein,"** etc., small flow of gas	3′	9″	453′	0″	557′	6″
59.	Fire clay	0′	6″	453′	6″	558′	0″
60.	Sandstone, micaceous	2′	6″	456′	0″	560′	6″
61.	Coaly streak	0′	1″	456′	1″	560′	7″
62.	Shale, gray, sandy	3′	11″	460′	0″	564′	6″
63.	Shale, gray, sandy with thin streaks of micaceous sandstone	20′	0″	480′	0″	584′	6″
64.	Sandstone, micaceous with thin layers of sandy shale	8′	0″	488′	0″	592′	6″
65.	Sandstone, hard, micaceous, with streaks of **coal** near base	22′	6″	510′	6″	615′	0″
66.	Fire clay, dark, sandy	5′	0″	515′	6″	620′	0″
67.	Sandstone, hard, gray, micaceous with streaks of **coal**	3′	6″	519′	0″	623′	6″
68.	**Coal (Upper Kittanning)**	0′	4″	519′	4″	623′	10″
69.	Fire clay, sandy in lower half	9′	2″	528′	6″	633′	0″
70.	Shale, gray, sandy	8′	6″	537′	0″	641′	6″
71.	Fire clay, impure, and sandy shales	9′	4″	546′	4″	650′	10″
72.	Sandstone, micaceous, shaly	3′	8″	550′	0″	654′	6″
73.	Sandstone, coarse, micaceous, pebby for 5 feet at base	27′	4″	577′	4″	681′	10″
74.	Shales, sandy, gray	4′	2″	581′	6″	686′	0″
75.	**Coal, Lower Kittanning**	0′	2″	581′	8″	686′	2″
76.	**Fire clay, good, Lower Kittanning**	20′	4″	602′	0″	706′	6″
77.	Shale, gray, sandy	3′	8″	605′	8″	710′	2″
78.	**Homewood sandstone**, top member of Pottsville series, flow of salt water and some gas at 608 feet, grayish white coarse sandstone	51′	10″	657′	6″	762′	0″
79.	Shale, gray, sandy	13′	6″	671′	0″	775′	6″
80.	**Coal, Upper Mercer**, 13″ fire clay in center	1′	7″	672′	7″	777′	1″
81.	Fire clay and sandy shales	12′	5″	685′	0″	789′	6″

		Thickness.		Depth.		Below Pittsburg Coal.	
82.	Sandstone, gray, micaceous	11′	0″	696′	0″	800′	6″
83.	Shale, gray, sandy.........	4′	0″	700′	0″	804′	6″
84.	**Coal, Lower Mercer, hard sulphurous**	1′	1″	701′	1″	805′	7″
85.	Fire clay..................	2′	6″	703′	7″	808′	1″
86.	Coal, bony.................	0′	4″	703′	11″	808′	5″
87.	Fire clay, dark, sandy.....	4′	6″	708′	5″	812′	11″
88.	Sandstone, micaceous......	3′	0″	711′	5″	815′	11″
89.	Shales, sandy..............	7′	0″	718′	5″	822′	11″
90.	Sandstone, hard, dark gray.	1′	7″	720′	0″	824′	6″

Regarding the section as a whole, the following observations appear to be sustained by its record:

The *Upper Freeport coal* is absent here as it is at most localities in Hancock county, where its horizon is above water level. The place where this coal belongs is at the base of No. 37, approximately 468 feet below the Pittsburg coal, and these figures (468 feet) represent the thickness of the Conemaugh series along the Ohio river, a decrease of a little more than 100 feet in that shown for the same measures along the Monongahela river 50 miles eastward.

The two prominent coal beds of the Conemaugh series; namely, the *Bakerstown* and *Brush creek* beds, are both easily recognizable in Nos. 20 and 33, respectively, although both are thin and unimportant. The *Bakerstown* coal was struck at a depth of 210 feet 10 inches, or 315 feet 4 inches below the Pittsburg coal, while the *Brush creek coal* was encountered in the boring at 332 feet 4 inches, or 436 feet 10 inches below the Pittsburg bed. This is the exact geologic horizon of the coal which is extensively mined in the summits of the hills at New Cumberland and which has heretofore been identified by the writer as the Mahoning or "No. 7 coal'" of Ohio. The record here given, adds force to the suspicion I have sometimes entertained; namely, that the *"Mahoning"* and *"Brush creek" coal* beds are very probably one and the same. If this be really true, as seems quite probable, then *Brush creek coal,* being the older name, should replace the term *"Mahoning coal."*

All of the fossiliferous limestones of the Conemaugh appear to be present; namely, the *"Ames," "Cambridge,"* and *Brush creek,"* at 93 feet 6 inches, 228 feet 4 inches, and 314 feet 2 inches in the boring, or at 198 feet, 332 feet 10 inches, and 418

feet 8 inches respectively below the Pittsburg coal. The shales in connection with these limestones, as well as the limestones themselves, teem with fossil marine life down to the *Brush creek coal* at 437 feet below the Pittsburg bed.

At a depth of 363 feet 9 inches, or 468 feet 3 inches below the Pittsburg coal, another kind of limestone was struck, however, which, with alternations of impure fire clay and calcareous shale continued for a thickness of 13 feet 3 inches. This limestone contains fresh water types of fossils, and doubtless represents the *Upper Freeport limestone* at the top of the Allegheny series, since it exactly resembles it in physical aspect and fossil remains. As is well known, this limestone immediately underlies the famous Upper Freeport coal bed which is such an important deposit of coal in eastern Monongalia, western Preston, Tucker, and adjoining areas, but is here completely absent, most probably because the Carboniferous forests which flourished at an earlier epoch (that of the Lower Freeport coal marsh) had been submerged and drowned by the invading sea whose arrival is heralded by the marine fossils in all the shales and limestones above the horizon of the Brush creek coal, through an interval of 240 feet of sediments. This same condition of affairs appears to have prevailed over practically all of Ohio, Brooke, and Hancock counties, so that this coal horizon so important in other regions of the Applachian basin, appears to be practically unrepresented along the Ohio river counties of West Virginia by any valuable coal deposit.

At a depth of 85 feet 6 inches below where the Upper Freeport bed belongs, however, or 553 feet 9 inches below the Pittsburg coal, the drill in the Glenova well struck a stratum of coal which is widely persistent along the Ohio river counties; namely,

The Lower Freeport Coal Bed.

This is the same coal that has been designated as "No. 5," "Steubenville shaft" seam, "Roger" bed, etc., by the Ohio geologists when it emerges to daylight along the Ohio river above Steubenville. Its occurrence in the Glenova well, taken in connection with its presence in the Central Glass Company's boring on Wheeling creek at a depth of 556 feet below the Pittsburg coal, as also its reported presence in borings at Moundsville, ten

miles below the mouth of Wheeling creek, renders it practically certain that this coal will be found under a large area of Ohio county, as well as that of Brooke. Should this coal extend under all of the 111 square miles of Ohio county's area with an average thickness of 4 feet, as appears probable, it would add about 300,000,000 tons of available good coal to the mineral wealth of Ohio county, and about 275,000,000 tons to the underground wealth of Brooke county, in a coal bed that does not appear at the surface anywhere within either county. In Hancock, however, this coal comes out to daylight and has been eroded to some extent, so that it does not underlie all of its 87 square miles of area, hence probably 200,000,000 tons would cover all of the available coal remaining in this bed within the limits of Hancock county. This would give a total estimate of 775,000,000 tons of available coal for the Lower Freeport bed in the three counties of Ohio, Brooke and Hancock, a large reserve supply for the great manufacturing districts of the Pan Handle region.

Owing to the fact that a "blower" of natural gas was struck when the drill penetrated this coal bed at Glenova, only a portion of the core was secured, and that probably mostly from the bottom part of the bed which is always highest in sulphur. The analysis of the samples of the coal saved gave the following results as reported by Mr. Leicester Patton, the Assistant Chemist of the Survey:

Proximate Analysis.

Moisture	1.05%
Volatile matter	36.00
Fixed carbon	54.86
Ash	8.09
	100.00
Sulphur	2.6
Phosphorus	0.008

Ultimate Analysis.

Carbon	75.27
Hydrogen	5.56
Oxygen	8.23
Nitrogen	1.18
Sulphur	1.67
Ash	8.09
	100.00
Calorimeter B. T. U.	13819
Calculated B. T. U.	13820

This analysis indicates a fuel coal of great excellence, and if crushed and purified by modern methods would undoubtedly burn into an excellent quality of coke, since the sulphur would be much lower than in the sample analyzed, and then the physical appearance of the coal shows it to be of the coking variety. Where this coal is mined by shafts in the vicinity of Brilliant, Steubenville and other points above Wheeling, the bottom portion of the bed, 8 to 14 inches in thickness, is often rejected and frequently separated when mined since it is high in sulphur, while the average in the coal above the bottom member is usually less than one per cent. A thin parting of slate generally separates the bottom member from the main portion of the seam above so that the upper and purer portion of this coal can be readily mined independent of the basal division. This is done at Brilliant, Ohio, just opposite Wellsburg, 14 miles above Glenova, where the Lower Freeport coal is mined by means of shafts 200 feet and more in depth, and has an average thickness of 3 feet 9 inches, the same as found in the Glenova boring. At Steubenville the LaBelle Iron Company is reported as using 2,000 to 2,500 tons of this coal daily for steam and gas producer purposes, the average thickness being 42 inches, of which the lower eight inches is rejected for the gas producer as being too high in sulphur. At the Steubenville Coal & Mining Company's shaft, the bed varies in thickness from 51 inches to 58 inches, and the bottom sulphurous coal has a thickness of 14 inches. The thickness of this coal at Steubenville is given on the authority of Mr. W. T. Griswold, as published on page 236 of this report. Both of these companies obtain the most of their coal from Brooke county, West Virginia, through galleries under the Ohio river, 100 feet or more below its bed.

The thin coal found at a depth of 519 feet in the middle of the Freeport sandstone series, and 76 feet under the Lower Freeport bed would appear to represent the *Upper Kittanning coal* of the Allegheny series, while the *Middle Kittanning coal* of the New Cumberland region, the same as No. 4 bed of the Ohio series, appears to have been completely cut out by the eroding current which deposited the coarse and pebbly basal portion of the Freeport sandstone, or No. 73 of the record.

The Freeport sandstone, which includes Nos. 64 to 73, has a thickness of 97 feet 4 inches, and is the same stratum as that seen at the Casparis quarry on Kings creek, Hancock county.

The *Middle Kittanning coal* is frequently cut out by erosion in Hancock county when the overlying Freeport sandstone becomes coarse and massive. This coal is doubtless present, however, in other portions of Ohio county, since its presence was recorded in the Central Glass Company's boring on Wheeling creek at a depth of 96 feet below the Lower Freeport coal, having a thickness of five feet.

The thin coal found at a depth of 581 feet 8 inches, or 686 feet 2 inches below the Pittsburg bed, appears to represent the *Lower Kittanning coal* since its horizon is 128 feet below the *Lower Freeport bed,* and this is the average interval which separates these two coals in the Ohio valley. This *Lower Kittanning coal* is not of much economic importance in the Ohio valley where it is known as *Coal No. 3,* being usually thin and impure, and entirely overshadowed in value by the great bed of fire clay which underlies it directly. This clay, known as the *Kittanning fire clay,* is represented by No. 76 of the record. It is this stratum which forms the principal basis for the brick industry at New Cumberland and other Ohio valley towns of that region.

In the Glenova boring this fire clay has the unusual thickness of 20 feet, and is of most excellent quality, so far as can be determined from physical structure and general appearance. The uppermost portion, seven feet in thickness, is light colored, while the rest of it is dark gray, both the "plastic" and "flint" varieties being represented in each color. When in the not distant future, shafts are sunk in the vicinity of Wheeling through which to mine the Lower Freeport coal, No. 58 of the boring, for either fuel or coke in order to supply the necessities of this great manufacturing center, it should prove a very profitable investment to continue these shafts down 120 odd feet lower into this great bed of clay which has yielded such rich returns to the industrial life of Hancock county and the neighboring towns of Toronto, East Liverpool and Wellsville just across the Ohio river.

It is possible that this bed of fire clay may represent the union of the Lower Kittanning and Clarion fire clays, since only 3′ 8″ under it the Allegheny series ends, and the top member of

the Pottsville series comes in at a depth of 605 feet 8 inches, thus cutting out entirely the presence of any members of the Clarion coal group, unless as suggested its clays could be represented in the lower portion of No. 76.

The Allegheny sediments appear to extend between No. 37 and No. 78, thus giving a thickness of (605 feet 8 inches—363 feet 9 inches) 242 feet, with only one coal bed (the Lower Freeport, No. 58) of commercial value. This unpleasant fact, so clearly shown by the record of the Glenova boring, is, I fear, also true of that great belt of counties shown on the geological map as lying westward from the outcrop to the east of the Allegheny-Kanawha series. Roughly, this belt of the Allegheny series so lean in coal, includes the entire area of the state westward from the Monongahela river from Morgantown and Fairmont on a line drawn through those cities southwestward along Elk river through Charleston, and on beyond to the Tug fork of Big Sandy in Wayne county. In fact, some of the counties westward from this line in which the Pittsburg coal is also absent, *may not have even one coal of commercial value.*

Should the rate of increase in coal production of West Virginia exhibited during the last ten years be maintained in the future (and there are no apparent reasons in sight to forbid it), the great Pittsburg coal bed underlying the counties of Brooke, Ohio, Marshall, Wetzel, western Monongalia, Marion, Harrison and other adjoining areas will be practically exhausted during the next 50 years.

It is a possibility like this which renders these deeply buried coals of the Allegheny series of great prospective value in the near future, especially to communities such as Wheeling whose industrial welfare is so intimately connected with the continuance of cheaply accessible fuel. These facts (of limited fuel supply) should also lead the state to find some effective remedy for the monstrous and unpardonable waste of this precious heritage, both in the methods of mining the coal and of manufacturing it into coke, in either of which a large percentage of fuel is irretrievably lost. Future generations will have great cause to condemn the awful extravagance of the present in wasting so ruthlessly the priceless stores of fuel, both solid and gaseous, with which bountiful nature has so richly dowered our beloved state.

No. 78 represents the *Homewood Sandstone,* the uppermost division of the *Pottsville series.* It is a massive, coarse, gray to white and often pebbly sandstone, some of the layers being extremely hard. In the basal ten feet at Glenova were found many fragments of shale pebbles. Just below the top of this sandstone at 608 feet, a small flow of gas was struck and with it an artesian flow of water containing some salt. There was also a slight showing of oil in connection therewith. This is the principal gas sand in the Majorsville field, near the eastern line of Ohio county, and it is also the stratum which furnishes the glass sand on Deckers creek in Monongalia and Preston.

Below this top member of the Pottsville there occur in western Pennsylvania and southeastern Ohio, two coal beds 25 to 30 feet apart, each of which is closely overlaid by a blue, fossiliferous limestone, the whole group of rocks being well developed near Mercer, the county seat of Mercer county, Pa., from which locality it was named. The famous Mt. Savage fire clay belongs in this group, and is usually found directly under the Upper Mercer coal. The group is enclosed between the Homewood sandstone above and the Connoquenessing sandstone, another member of the Pottsville, below, and including the shales has a thickness of 40 to 70 feet in western Pennsylvania. Neither of these coals seldom exceeds 3 feet in either Pennsylvania or Ohio, and both are frequently much less, although the coals as well as the thin (2′-3′) overlying limestones appear to be entirely persistent around the northern border of Ohio's coal field from Mahoning county on the east to the "Hanging Rock" district in Lawrence on the west. These two Mercer coals (Upper and Lower) appear to be represented by Nos. 80 and 84 of the record.

Although this group is so thin and unimportant in the northern region of the state, it is believed by Mr. David White, the eminent paleobotanist of the U. S. G. Survey, that this group expands southwestwardly and eventually comprises a large portion of the Kanawha coal series.

The limestones of the group appear to be completely absent at Glenova.

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PART IV.—The Climate and Soils of the Pan Handle Area.

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AUTHOR'S PREFACE.

In writing the present report on the geology of the Pan Handle counties, an effort has been made to state the facts in a style intelligible to the people of those counties and of the State, at the same time not losing sight of scientific accuracy.

To the trained geologist, many of the discussions may appear old and worn, and from his point of view, perhaps could well be omitted; but most of the people within the borders of these counties are not familiar with these subjects. Technical descriptions clear to the geologist, are often without significance to people following other lines of work. The volume includes information along the lines of local geology and local industries which should prove serviceable to the public school teachers in their work of instruction.

Scientific agriculture has become a subject of interest and importance to the farmers, and while they do not accept all the theories advanced under this head, they do see the value of many suggestions offered by trained investigators in these lines. The study of the soils, their good and bad characters, the corrective methods and materials, are subjects of such importance that the government has established at Washington a Bureau of Soils. Arrangements have been made for co-operation between this department and the State Survey, whereby the soils of the counties will be studied, their varieties marked in colors on maps, and the methods of improving the soils investigated. One of the first of these reports is included in this volume, and is the work of two trained men with a number of years' practical experience in soil study, Mr. T. A. Caine and G. W. Tailby, Jr., whose careful report deserves special attention.

The report on the Pan Handle area includes a brief history of the counties and their development. It contains a study of the surface features of the county, in reality a chapter on physical geography applied to the counties which should be of interest and value to the teacher in the schools and the people outside the school. Hills and valleys, runs and rivers have a history, similar

in some ways to that of people and nations, and in this chapter attention is directed to a subject that may be new to many.

The chapters on general geology, while from the nature of the subject, technical, give detailed information about the rock formations, and give the generally accepted classification of the rock strata which permits comparison with the formations in other counties and states. The chapters on economic resources of the Pan Handle counties represent the dollars and cents or commercial aspects, and will form the advertisement of the mineral wealth of these counties.

The review of the climate includes all available data on this subject, and is arranged in tables and diagrams so as to be ready for reference at all times. There can be found the coldest year, month, or day, and the warmest, subjects of popular interest, and the average conditions of temperature, rainfall, etc., all of practical value.

A series of maps accompany the volume and show by the use of colors, the character of the surface, the roads, streams, railroads. etc. They also illustrate the general geology of the area, the outcrops of coal seams, mines, wells, and other data on the mineral wealth. The soil map shows the character and distribution of the soils. These eight maps form a valuable feature of the report.

In the preparation of this volume, one field season and parts of two others have been devoted to the work in these counties. During a part of the season of 1905, Mr. Ray V. Hennen and Frank F. Grout, of the Survey staff, aided in the field work. Valuable assistance has been rendered by many persons in these counties in furnishing data on history, records of wells, etc. Their co-operation has aided in making the report more complete.

The government departments have at all times been willing to co-operate in this work, including the U. S. Weather Bureau, U. S. Geological Survey, Bureau of Good Roads, and Bureau of Soils. Mr. W. S. Griswold of the U. S. Geological Survey, with the permission of the Director, has contributed the report on the coals of the Steubenville Quadrangle, forming chapter VIII. Prof. Milton Whitney, Chief of the Bureau of Soils, has furnished advance sheets of the soil report, forming chapter XII. Mr. Alex. McC. Ashley, of the U. S. Weather Bureau, at Pittsburg, and Mr. H. C. Howe, of the same Bureau at Parkersburg,

have furnished valuable data on the Ohio river stages and the weather. Other persons who have furnished information are mentioned in the text.

The chemical analyses have been made in the Survey laboratory by Mr. Leicester Patton, assistant chemist, under the direction of Professor B. H. Hite, chief chemist. The careful determinations made on heating value of coals and the ultimate analyses, as well as the general analyses of coals, limestones, clays, etc., add to the value of the report, and acknowledgment is made for the promptness and accuracy of this work.

It is a pleasure again to express my appreciation for the aid of the State Geologist, Dr. I. C. White, whose writings and suggestions have added to the value and completeness of this report.

G. P. GRIMSLEY.

Morgantown, W. Va., January 25, 1907.

ERRATA.

Page 22, 15th line from top for "It thus" read It is thus.
" 49, 2nd line above table for "short distance" read narrow limits.
" 50, 7th line from top for "heavier" read greater.
" 54, 7th line from top for "cross road" read cross roads.
" 57, 9th line from bottom for "John A." read John J.
" 71, 21st line from top for "were" read are.
" 73, 12th line from top for "Pocopteris" read Pecopteris.
" 73, 12th line from top for "Boiera" read Baiera.
" 74, 13th line from top for "terraces" read terranes.
" 80, 10th line from bottom for "agillaceous" read argillaceous.
" 88, 9th line from bottom for "land" read lands.
" 117, 14th line from bottom for "flag" read flaggy.
" 119, 24th line from bottom for "Ames" read the Ames.
" 128, top line for "cribosum" read cribrosum.
" 133, 7th line from bottom omit "Mason."
" 135, 5th line from top for "on the" read of the.
" 142, 19th line from top omit "Roaring Creek."
" 142, 22nd line from top omit "and in Randolph county, West Virginia, the Roaring creek."
" 150, 16th line from top for "in Middle" read in the Middle.
" 151, 14th line from top for "followed" read extends.
" 157, 16th line from bottom for "180 square miles" read 180 miles.
" 158, 16th line from bottom for "down the river" read up the river.
" 162, 7th line from bottom for "by products" read by-products.
" 164, top line "coals in the Dunkard Series" belongs top page 165.
" 168, 13th line from bottom for "in Waynesburg coal" read in the Waynesburg coal.
" 178, 7th line from bottom for "and half" read and a half.
" 184, 12th line from bottom for "analyses" read analysis.
" 196, 4th line from top for "Brooke" read the Brooke.
" 205, 4th line from top for "1.78" read 4.78.
" 227, 11th line from bottom for "bottoom" read bottom.
" 262, Between 11th and 12th lines from bottom of table insert line
Shale....................52 480
" 262, 11th line from bottom of table for "448" read 484.
" 263, 16th line from bottom for "1575" read 1595.
" 311, 2nd line from bottom for "1.42 degrees" read 142 degrees.
" 326, 5th line from bottom for "shows" read show.

PART I.

The History and Physiography of the Pan Handle Area, West Virginia.

CHAPTER I.

THE HISTORICAL AND INDUSTRIAL DEVELOPMENT OF THE PAN HANDLE COUNTIES.

LOCATION AND HISTORY.

The northern Pan-handle of West Virginia includes the area north of the western extension of the Mason and Dixon line, between the Ohio river and the western boundary of Pennsylvania. This long, narrow territory includes 605 square miles comprising the counties of Marshall, Ohio, Brooke, and Hancock, the last three forming the subject of the present volume and including an area of 294 square miles, as follows: Ohio, 111; Brooke, 97; and Hancock, 86 square miles.

The explanation of this peculiarly shaped northward extension of the state is to be found in the history of the original land grant to Wm. Penn. It was finally marked out by the survey of the Mason and Dixon line and by the settlement of the boundary disputes between the states of Pennsylvania and Virginia. The tract was named the "Panhandle" in the course of legislative debate, by Hon. John McMillan, a delegate from Brooke county.

It was in the year 1767 that the south line of Pennsylvania was surveyed by the two English engineers, Mason and Dixon, who were ordered to establish a line westward for five degrees of longitude from a starting point fixed on a circle forming the north boundary of the state of Delaware. This survey was carried west to a point near the present town of Mount Morris, west of the Monongahela, where the line was terminated or

account of the hostility of the Indians. The two engineers calculated the line should be continued westward 23¼ miles, and the work was left incomplete.

The territory of the Pan-handle was then claimed by Pennsylvania and Virginia, both states granting deeds which later led to serious disputes. In 1780 a commission was appointed by Pennsylvania and Virginia to settle the doubtful southwestern corner of Pennsylvania and establish the boundary lines between the two states. The members of the commission agreed to fix the boundaries by a line drawn at five degrees of longitude west from the Delaware river, thence north to the northern boundary of Pennsylvania. The corner was carefully established, and the northward line surveyed to the Ohio river, where the work stopped on account of hostility of the Indians.

The report of the commission was submitted to the two states in December, 1784, accepted and adopted by the Legislature of Virginia on October 8, 1785, and from that date the Pan-handle has been legally a part of Virginia.

This district has been prominent in history from an early date. The French entered the country in 1739, and established their claims to the territory in 1749 by the burial of a series of lead plates properly inscribed. Before the revolutionary war there was a considerable number of white settlers, who were more or less troubled by the Indians, and the early records of these brave settlers contain numerous accounts of Indian massacres and battles. The Zane family located at the site of Wheeling about the year 1760, and a little later at this place Fort Fincastle was erected, and its name changed in 1776 to Fort Henry, in honor of Patrick Henry, the Virginia patriot.

In November, 1776, the district of West Augusta, which included most of the present territory of West Virginia west of a line drawn south from the western boundary of Maryland, was subdivided into three districts or counties; Youghiogheny, Ohio, and Monongalia.

Ohio county included the territory south of Cross creek (center of present Brooke county), and west of the dividing ridge between the waters of the Ohio and Monongahela, and north of a line drawn between the head waters of the Cheat and Greenbrier rivers continued westward to the Ohio river.

After the settlement of the boundary between Pennsylvania and Virginia, with the readjustment of county lines in 1789, the portion north of Cross creek to the Ohio river was added to Ohio county, and Youghiogheny county disappeared from the map.

In 1795, with the close of Wayne's campaign and the complete defeat of the Indians, the Pan-handle country was rendered safe for settlers. The boundary disputes and battles had directed attention to this territory so that the population rapidly increased. In 1779 Brooke county was formed to include the territory north of Short creek. In 1835 Marshall county was formed from the southern part of Ohio; and in 1848, Hancock county was separated from the upper end of Brooke county.

HISTORY OF TRANSPORTATION.

OHIO RIVER.

The great value of the Ohio river as a carrier of trade was early recognized, and the towns and cities located on its banks became important commercial points on the western frontier. In the Pan-handle district, Wellsburg and Wheeling were large shipping and boat building centers with considerable rivalry between them. In 1820 the exports of flour and whisky from Wellsburg exceeded Wheeling and closely rivalled Pittsburg, 2,000 arks and barges, according to the old records, plied their trade along this waterway.

The Ohio river is open for navigation the greater part of the year, and with the completion of the government dams and locks now under construction the river will be open with a nine foot stage practically the entire year. During 1905 the river traffic at Wheeling amounted to 200,000 tons, and in addition 70,000 passengers were carried. According to Major Warren the entire tonnage on the Ohio that year amounted to 13,463,156.

NATIONAL ROAD.

In 1802 Congress, appreciating the need of better communication with the western country, passed the National Road bill for the construction of a public highway to Cumberland, Md., and March 29, 1806, a bill was passed for the continuation of this road to the Ohio river. The route as far as Brownsville, Pa.,

was selected and approved in 1808, and construction began in 1815. In the next two years $1,800,000 had been expended when the question of abandonment of the enterprise was raised, but it was decided to continue the work.

In 1817, after a hard fight between Wellsburg and Wheeling for the Ohio river terminus, the latter point was selected, mainly through the influence of Henry Clay who favored Wheeling. The road was completed in 1818 at a cost of $7,500,000. The travel over this national highway was heavy from the time of its completion, yet the tolls collected were not sufficient for the repairs, and by 1825 the road was so bad, especially from Brownsville to Wheeling, that an attempt was made to change the route to Wellsburg, but Clay's influence again defeated the proposed plan.

In 1827 a line of through coaches running day and night was established, and later rival lines were started, which, with the large freight wagons, formed an almost continuous line. This heavy traffic continued until the Baltimore & Ohio railroad was completed to Wheeling at the end of the year 1852, and in a few months the days of the stage coach and freight wagon were ended. The road was transferred to the state in 1836 and tolls were abolished in Ohio county on June 15, 1901.

Recently statements have been made in public lectures and thereby reached the press, calling attention to the deplorable condition of this historic road in West Virginia. As a matter of fact the road is kept in good condition through Ohio county with the exception of a few places within corporate town limits, and the work of replacing these sections with brick paved streets is now well under way. Ohio county instead of being cited as an example of poor roads, is exceptional in the number of miles of good roads with nearly all the mileage macadamized. The National road of today in Ohio county is in good condition, probably far better than it ever was in the days of the stage coach traffic, and its condition reflects credit on the county.

WELLSBURG TURNPIKE.

In 1808 a charter was issued for the construction of a road from Philadelphia to Wellsburg, the original charter stating "it is contemplated to build a continuous highway from the city of Philadelphia and from the Potomac river to Charlestown

(Wellsburg) to intersect the federal highway from the Potomac to the Ohio at some point between Washington and Brownsville, Pennsylvania."

After the granting of the charter nothing further was done until 1825, when the bad condition of the National road gave hope of deflecting it to Wellsburg. At this time the stock in the Wellsburg turnpike was subscribed, the route surveyed, and construction started, but with the final decision to continue the National road to Wheeling the work practically ceased, and its completion was the slow work of many years.

The Wellsburg and Bethany pike was engineered and graded in 1850, though the old road had been improved from time to time before this date. The Bethany pike is unique in having two tunnels cut through the solid sandstone rock. These tunnels were made in 1831 and 1833 by Richard Waugh, a prosperous miller, at his own expense.

BALTIMORE & OHIO RAILROAD.[1]

The plan of building a railroad from Baltimore to the Ohio river was first proposed at a meeting of business men in Baltimore, February 12, 1827. A week later a plan for the organization of the Baltimore & Ohio railroad was formulated and a committee was appointed to secure an act of incorporation from the legislatures of Maryland, Virginia, and Pennsylvania, which act was passed February 27, 1827, fixing the capital stock at $3,000,000 in 30,000 shares of $100 each.

The board of directors was organized April 23, 1827, the work of construction commenced, and the road was opened to Frederick, Maryland, December 1, 1831. The line was completed to Cumberland, November 5, 1842, and no further work done until 1849, when the construction was resumed westward and completed to Wheeling, January 1, 1853.

The Parkersburg branch was completed in 1857, and in 1871 the B. & O. purchased the "Hempfield" railroad, operating a line from Wheeling to Washington, Pa., and completed the road to Pittsburg.

The Central Ohio railroad was chartered in Ohio in 1848 and opened from Zanesville to Newark in 1849, continued to

1. The data on railroads in Ohio county are taken from a series of articles in the Wheeling Daily Telegraph.

Columbus in 1850. In 1852 terminal facilities were acquired in Wheeling. The road was leased by the B. & O. in 1865, and the Bellaire bridge completed in 1871.

PENNSYLVANIA RAILROAD.

In 1834 the Pittsburg & Waterford railroad was projected from Washington, Pa., to the Ohio canal at Stillwater, Ohio, crossing the river at Wellsburg. On the 4th of July, 1854, six miles of this road were completed to the Pennsylvania line, but the project was later abandoned. In March, 1860, a charter was granted for the Holliday's Cove Railroad Co., and a right of way secured for a branch to Wellsburg, but nothing further was done until July 15, 1868, when a charter was issued for a railroad from Steubenville to Wheeling, later amended so as to reach the Kentucky state line. February 16, 1871, the corporate name of this road was fixed as the Pittsburg, Wheeling & Kentucky R. R., and construction began the next year. The road was completed to Wellsburg in 1878, and in February of that year was leased to the Pennsylvania Railroad Co., which completed the road to Wheeling, where it was extended to Benwood, connecting with the Ohio River railroad. The northern extension to New Cumberland was completed in 1884, and continued to Chester in 1899.

OHIO RIVER RAILROAD.

The charter for the Ohio River railroad was issued in April, 1881, under the name of the Wheeling & Parkersburg railroad, but received its present name in December, 1882. The railroad was completed to Benwood in June, 1884, the trains running into Wheeling over the Pittsburg, Wheeling and Kentucky tracks. The river road reached Point Pleasant in January, 1886, and Huntington in April, 1888. This road is now operated by the Baltimore & Ohio.

CLEVELAND. LORAIN & WHEELING RAILROAD.

This road was built in 1876 from Dennison, Ohio, to Bridgeport, and in 1888 was extended to Bellaire and later to Martins Ferry. It was connected with Wheeling by the Wheeling Terminal, but now enters Wheeling over the Baltimore & Ohio, which operates the system.

WABASH RAILROAD.

In 1872 the Wheeling Union railroad was incorporated to give an outlet to the lakes, but the project was abandoned, and this connection was made later by the construction of the Wheeling & Lake Erie railroad, now owned by the Wabash. The road has been extended eastward to Pittsburg, crossing the Ohio river at Mingo Junction and following the valley of Cross Creek across the Pan-handle.

In 1887 the Wheeling Bridge & Terminal R. R. Co. was formed to connect Wheeling with the northern roads across the river, and also to connect the city with the coal and coke fields of Pennsylvania. The road and bridge were completed in August, 1891, and when the Wabash purchased the Wheeling & Lake Erie railroad they also secured the traffic contract the latter held with the Terminal.

The Wabash has recently made surveys for a short line from Wheeling to the coke regions of Pennsylvania, and the Baltimore & Ohio has been at work on surveys for a similar purpose. It seems almost certain that in the near future one or two short line roads will greatly reduce the railroad distance to the Pennsylvania coking coal district.

GENERAL DESCRIPTION.

OHIO COUNTY.

Ohio county has an area of 111 square miles and varies in elevation from 610 feet at the Ohio river to 1440 feet just south of the National road near the Pennsylvania line.

Since 1771, when Col. Ebenezer Zane, the founder of Wheeling, planted the first acre of corn in the Ohio valley, this district has been known as a rich agricultural area. The county is devoted to farming and pasturage for fine cattle, horses and sheep. The agricultural products amount to over $350,000 a year, and 126,516 pounds of wool were shipped to market in 1904.

Small towns are scattered here and there over the county. Most of these contain fine homes, public schools, and churches, and are supplied with natural gas fuel. Following the National road to the east line of the county there is almost a continuous line of residences, grouped here and there into corporate towns, connected with each other and with Wheeling by the Wheeling & Elm Grove traction car line.

These towns, especially near Wheeling, have had a rapid growth, many new additions are being surveyed and fine houses erected. Along the National road from Wheeling to the Pennsylvania line are the towns of Fulton, Woodsdale, Woodlawn, Leatherwood, Edgington, Echo Point, Whitfield, Pleasant Valley, Elm Grove, Triadelphia, Roney's Point, Point Mills, Valley Grove, and over the state line, West Alexander. To the south of this road are the towns of Mont de Chantal with its well known Catholic seminary, Patterson, Twilight, and Dallas.

To the north of Wheeling a number of suburban towns have been started along the Wheeling & Wellsburg traction line. Among these are Warwood, Glenn's Run, and Willow Spring. Further north are the towns of Potomac, Clinton, Shannon, and West Liberty, the seat of one of the state's excellent and prosperous normal schools.

Wheeling.

The most important city and the largest in the state is Wheeling, located in the southwestern part of the county on the Ohio river.

It was first settled by the three Zane brothers in 1769, and in 1773 was plotted as a town site with 112 lots. The town was incorporated in 1806 and raised to the rank of a city in 1836. This same year the island was plotted to form the town of Columbia. In 1796, forty log houses comprised the town of Wheeling, which had a population of 500 in 1800. In 1820 it had grown to 1,567, and at the present time has 45,000 people within the city limits, or counting the tributary towns in West Virginia and Ohio, is a community of 120,000 people.

The first court in Ohio county was held at Black's Cabin on Short Creek (now West Liberty) in 1777, but was removed to Wheeling in 1779. When the state of West Virginia was formed in 1863 Wheeling was made its capital, and remained so until 1870, when Charleston became the capital of the state. Wheeling again became the capital in 1876 and remained so until May 1, 1885, when Charleston was made the permanent capital.

Wheeling is a prosperous industrial city, with a banking capital of over $2,000,000 and $18,000,000 of deposits, the annual wholesale business amounts to $20,000,000, with an additional retail trade of $10,000,000. In the city and suburbs are 80 miles

of street railway lines. The yearly railroad and river traffic is over 5,000,000 tons, and the industries are varied, but especially prominent is the iron and steel industry, which reperesents an investment of $50,000,000, also the pottery, glass, calico, tobacco, and brewing plants. A brief account of the rise and growth of the more important mineral industries will now be given.

Iron and Steel Industry.

About 1834 the "Top" iron mill at the north edge of Wheeling was erected by Schoenberger & Co., as a bar mill, and made a few nails. It was called the Missouri Iron Works and operated by David Agnew. Later it was operated by Atchison, Bell & Co., as the Wheeling Iron & Nail Works, then changed to the Wheeling Iron & Nail Co., making 8,000 to 10,000 kegs of nails a week. The plant is now owned by the Wheeling Steel & Iron Co.

Some years later than the building of the Top mill, Bailey, Norton & Co. built a nail factory at the mouth of Wheeling creek about the location of the present B. & O. station. The site was later sold to the B. & O. railroad and the iron company erected the Belmont mill. The company afterward dissolved partnership, Bailey and others built the LaBelle plant, while other members of the firm built the Bellaire mill. Kelly, Halloway & Co. erected the present Benwood mill with 240 nail machines.

There were at one time in Wheeling seven nail mills, with 1140 machines, and an annual capacity of 2,830,000 kegs of cut nails, and the city was the greatest nail center in the world and known as the "Nail City." Then came the great strike of the nail machine workers, closing down the plants for a number of years. During this time the wire nail was invented and made on a large scale at Pittsburg, displacing the machine-cut nail, and the Wheeling factories were dismantled or abandoned, so that at the present time this industry is very small.

The present iron and steel industry of Wheeling is concentrated in a few large plants.

Wheeling Steel & Iron Co., operates five mills: the Top and Belmont mills in Wheeling, the Benwood mill, Benwood steel works, Benwood pipe mill. Their daily capacity is 650 tons of steel billets, 300 tons wrought pipe, 500 tons steel skelp, 100 tons of iron skelp, 50 tons of steel and iron sheets, and 600 kegs of cut

nails. Their specialties are listed as wrought iron and steel pipe, special soft Bessemer, high carbon Bessemer, high carbon shovel steel, tack plate, steam, gas and water pipes are made in any sizes from ⅛ inch inside diameter to 12 inches.

The Riverside Plant of the *National Tube Co.* was started in 1866 by Dewey, Vance & Co. It consisted of a bar mill and nail factory, manufacturing light rails, bars, nails, and was later incorporated as the Riverside Iron Co. In 1870 furnace **A** was built and placed in operation in February, 1872. The steel works were added in 1884, and in 1887 the tube mill was completed, making gas pipe, casing, boiler tubes, bedstead tubing, hollow brake tubes for railroad use. In 1885 the large plate mills were erected to manufacture skelp for the tube plant. Furnace **B** was first used in March, 1903. The company now employs 3000 men, with a blast furnace capacity of 700 to 800 tons a day. The skelp mill turns out 600 tons daily, and the tube mill 500 tons.

The La Belle Iron Works operates a large plant at Steubenville and a smaller one at Wheeling, the latter having a daily capacity of 250 gross tons of basic open-hearth boiler tube skelp, nail and tack plate, and 1000 kegs of cut nails.

The Wheeling Mold & Foundry Co. built their first plant in Wheeling in 1901, and now have three plants making especially chilled and sand rolls, rolling mill machinery, and ingot molds. The company is now engaged on a contract of 70,000 tons of iron casings for the North and East river tunnels of the Pennsylvania railroad at New York city. Three hundred to four hundred men are employed and the business of this company last year amounted to $800,000.

Semet-Solvay Company. At the Riverside plant of the National Tube Works the Semet-Solvay Company has installed a by-product coking plant consisting of one battery of 60 retorts, three flues high, and a second battery of 60 retorts, four flues high. The retorts built of fire brick are 30 feet long, 16 inches wide and 5½ and 7 feet high. The smaller retorts hold 5.1 tons of coal each. The coal is charged from above through three openings, and the coal is leveled and unloaded by a traveling stoking machine. The coal yields 70 per cent coke, or 500 tons in 24 hours from the two batteries, and is used by the Riverside plant. The other products saved are gas, coal tar, ammonia and

napthelene or oil of tar, which is shipped in iron tank cars to other plants of the company where it is refined and used for carburation.

Connellsville coal is used with the following average composition:

Moisture	0.54
Volatile combust. matter	30.54
Fixed carbon	59.68
Ash	9.24
Sulphur	0.98
Phosphorus	0.013

The coke manufactured shows the following composition in the sample selected, though this coke was not made from the car of coal analyzed above. An analysis of standard Connellsville coke made in bee-hive ovens is added for comparison.

	By-product coke.	Connellsville coke.
Volatile combustible matter	1.95	1.31
Fixed carbon	87.17	86.88
Ash	10.88	11.54
Sulphur	0.68	0.695
Phosphorus	0.007	0.005

Glass Industry.

The first glass factory was erected by Samuel Cuthbert at Wheeling near the present Top mill in 1821 for the manufacture of window glass. In 1829 Mr. A. J. Sweeney erected a glass plant at Wheeling for the manufacture of table ware and also cut glass. It was at this plant that two very large cut glass bowls, five feet in height, were made in 1844, probably the largest specimens of cut glass in this country. One of these pieces was presented to Henry Clay by his Wheeling friends, the other remained in the possession of the Sweeney family and now forms a fitting monument over the grave of the pioneer glass manufacturer, M. Sweeney, in Greenwood cemetery, two miles east of Wheeling.

In 1832 Wheat, Price & Co. started a flint glass factory in South Wheeling and sold the same to Plunkett & Miller in 1837. This plant was operated until 1840 and then closed. It was purchased in 1845 by Hobbs & Barnes, and in 1862 was owned by Hobbs & Brockunier, who operated it until 1898 when it was sold to H. Northwood. In the early history of this plant the pots held 1500 pounds of lead glass; and in the later work 3800-

pound pots were used and the manufacture changed from lead glass to soda lime glass.

In 1832 John and Craig Ritchie started the manufacture of bottle glass at the present site of Market alley and Chapline street, but the plant was removed in a short time. About the same time Anderson Brothers built a bottle factory at the present site of Chapline and Twentieth street. At Twenty-third and Chapline, Henry Teater built a window glass factory in 1832. In the early fifties a tableware factory was started in central Wheeling.

Wheat, Price & Co., after selling their plant in 1837, built a factory at Ridgetown, now the lower end of Wheeling, which was operated by a Mr. Miller, who brought skilled workmen from the New England Glass Co., of Boston. Among these men was Hobbs, who operated the South Wheeling plant in 1845. The Ridgetown factory was later operated under the name of the Crown Glass Co., by John and Craig Ritchie & Wilson.

In 1862 nine young men from the Hobbs & Brockunier factory bought the old slaughter house up Wheeling creek and made glass under the firm name of Osterling, Henderson & Co., and in 1868 the name was changed to the Central Glass Co.

The Wheeling glass industry is thus seen to be 75 years old, and its products in these early days were of high grade, and attracted attention in the markets.

The Wheeling district became a prominent center, and Bellaire, across the river in Ohio, grew to be one of the leading glass manufacturing towns of the country, with 18 factories.. Other plants were located along the Ohio river in Ohio and West Virginia. With the opening of the northern Ohio and Indiana gas fields, and the inducement of free factory sites and free gas fuel, many of the plants were moved to those sections and the old plants abandoned. In 1889 there were three glass factories in Wheeling with seven furnaces and 72 pots, representing an invested capital of $500,000, giving employment to 900 people.

At the present time the Central Glass Co. employs 600 to 700 people with annual sales of nearly $500,000. The plant is equipped with three furnaces containing 36 pots, and manufactures thin blown lead glass tumblers, pressed tumblers, bar and hotel ware, and cut glass. Gas fuel is used throughout the plant. Two large brick buildings are in use, one for storage and offices, the other

Plate I.—Pleasant Valley on North Fork, Tomlinson's Run, Hancock County.

at the side of the B. & O. railroad, contains the furnaces and factory.

The H. Northwood Glass Co. operates the old Hobbs & Brockunier plant, and makes a specialty of decorated table ware, colored and plain, gas and electric shades, pressed ware for table and bar use, lamps, lemonade and wine sets, and novelties in opalescent colors. The tinted and colored glass is made in a variety of beautiful shades and finds a large sale. There are two furnaces with 28 pots, fired with natural gas. Four hundred persons are employed, and the annual sales reach $300,000.

The North Wheeling Glass Co. was started in September, 1878, and rebuilt in 1882. The plant is equipped with one 14-pot furnace and a 17-ton tank. Flint glass bottles are made in various shapes and sizes, and 150 people employed.

Pottery Industry.

The first pottery for the manufacture of white ware in West Virginia began work at Wheeling in 1879 under the name of the Wheeling Pottery Co. The plant was located at the corner of Chapline and Thirty-first streets and contained seven kilns. The products were plain white granite table and toilet ware. In 1882 the first kiln for decorated ware was added.

A second pottery was built in 1889 at the corner of Wood and Thirty-first streets in South Wheeling, under the name of the La Belle plant, making at first ordinary white ware, and later the fine grades of china.

A third pottery was erected in North Wheeling in 1890 by the West Virginia China Co., manufacturing vitrified hotel china. Later this plant was operated by Anton Reymann under the name of the Ohio Valley China Co., and made a hard paste porcelain or china. In 1899 the pottery was sold to the Riverside Pottery Co. and changed to the manufacture of sanitary ware. In 1905 these several plants were consolidated under the name of the Wheeling Potteries Company, capitalized at $1,000,000, which now operates 27 white ware kilns, and 20 decorating kilns.

BROOKE COUNTY.

Brooke county was organized in 1797 and reduced to its present area in 1848 by the formation of Hancock county. Its area is

97 square miles, ranging in elevation from 657 feet at the Ohio river to 1377 feet near the south line of the county north of West Liberty.

Like Ohio county, Brooke is a rich farming district and also prominent in sheep raising. In the early days the county was devoted to the raising of grain, and numerous grist mills were located along the streams which furnished sufficient water power. With the flour mills were associated the distilleries, and flour and whisky were staple articles of trade until the great temperance revival of the early thirties, which, combined with the decreasing fertility of the soil for crops of grain, gradually closed the industry, so that by 1845 not one distillery remained in the county.

Many of the old flour mills with the distillery annex are still standing marking the sites of the former industry, but only here and there does a solitary grist mill continue its work. The raising of grain, year after year, finally exhausted the soil for such crops, and their yield greatly decreasing caused a change to pasturage and sheep raising. The soil at the present time by the use of fertilizer and rotation of crops has been restored, but the milling interests were not renewed.

The important towns of Brooke county are Wellsburg, Lazearville, Follansbee, Collier, and Bethany, the seat of Bethany College, one of the old and honored institutions of higher education in the state. The towns along the Ohio river are connected with each other and with Wheeling and Steubenville by the Pennsylvania railroad and the Pan Handle traction car lines, while the Wabash and Pennsylvania railroads cut across the county, giving connection with Pittsburg. A new traction car line is now under construction from Wellsburg to Bethany.

Wellsburg.

The largest town in Brooke county is Wellsburg, the county seat, with a population of 5,000. It was first settled in 1772, and laid out as a town site in the fall of 1790 under the name of Charlestown, after Charles Prather, its owner and founder. The first court was held in 1799, and in 1816 the name was changed to Wellsburg in honor of Alexander Wells, a son-in-law of Prather. The main industries of the town are foundry work, glass, wrapping and manilla bag paper manufacture.

The Glass Industry.

As early as 1813 Isaac Duval & Co. erected a flint glass factory at Wellsburg near the site of the present Riverside glass works, and it was operated with varying degrees of success until 1842.

In 1836 the Markley Brothers erected a green glass factory which was in operation two years and then closed. In 1850 interest was revived in the glass industry and in 1855 the Metcalf & Miller Glass Co. was selling $25,000 worth of ware a year, but later failed. At the present time there are five glass plants in Wellsburg and the adjoining town of Lazearville, employing about 1,000 people.

The Eagle Glass Co., of Lazearville, was established in January, 1894, and operates a plant of 70 pots. Its decorating department and ware rooms occupy 45,000 square feet of floor space, and a new large addition has been completed.

The company manufactures an extensive line of decorated lamps. lamp shades, druggists' sundries in opal, flint, and amber glass, and a large variety of novelties in plain and decorated ware.

The Riverside Glass Co. built their first plant in January, 1880. It was later destroyed by fire and rebuilt and sold to the National Glass Company in 1900, when it was operated as factory 15 of that company. In 1904 the company was reorganized under the name of the Riverside Glass Co. The plant is equipped with one ten-pot, one six-pot furnace, also with one tank. Two hundred and ten people are employed in the manufacture of table ware, lamps, and stationery glass ware.

There are two bottle glass factories at Wellsburg, the Union Bottle Glass Co., and the Tanner-French Company. The Wellsburg Glass & Manufacturing Co. are engaged in specialty goods.

Follansbee.

The town of Follansbee, four miles north of Wellsburg, was started June 1st, 1904, and now claims a population of 1600. The Follansbee brothers, who founded the town, have erected a 10-furnace tin plate mill which employs 500 men.

There is also a large metal construction plant established here, and the Jefferson Glass Co. has completed a 16-pot glass plant

for the manufacture of decorated and opalescent crystal glass ware.

HANCOCK COUNTY.

Hancock county, named in honor of John Hancock, president of the Continental Congress, was formed in 1848 from the northern portion of Brooke county. It has an area of 86 square miles and is the smallest county in the state. The elevation ranges from 666 feet at the Ohio river to 1337 feet on the high hill south of Chester.

According to the census of 1900, the population of the county was 6,693. There were 427 farms, ranging in size from one or two acres to over 500, with a total value of agricultural products of $92,459. It is the leading fruit county in the state outside the eastern Pan Handle, and yielded in 1896, 100,000 bushels.

The towns in the county are mainly small and few in number. Holliday's Cove, New Cumberland Junction, Zalia, Fairview, Congo, New Cumberland, Newell, and Chester. All except Fairview are on the Pennsylvania railroad, a branch of this system following the river to Chester.

New Cumberland.

New Cumberland, the county seat, was plotted as a town site with the name of Vernon by John Cuppy in 1839. With the sale of the lots the name was changed to New Cumberland, and the first house was erected in the spring of 1840. When the county was organized in 1848, New Manchester (Fairview), was made the county seat after a bitter struggle, but changed to New Cumberland on December 27, 1884.

This town is in the center of the State's most important brick and clay industry, which will be described in another chapter.

Chester.

Chester, located at the northern edge of the county, on the Ohio river, was founded in 1890. The town is connected with East Liverpool, Ohio, by traction car line. Its largest industry is the tin plate mill of the American Sheet & Tin Plate Company. This

plant, built in 1900 or 1901, contains seven mills with a capacity of 350 to 400 tons of plate a week, and employs 1,000 people. All grades of tin plate are made, including the common cokes, high grade terne plate for roofing, and dairy plate. There are two large white ware potteries which will be described in the chapter on economic resources of the Pan Handle counties.

The town of Newell is located about two miles below Chester on the Ohio river, and was started in 1905, and is the location of one of the largest white ware potteries in the world.

CHAPTER II.

THE PHYSIOGRAPHY OF THE PAN HANDLE COUNTIES.

The study of the surface features of the land, the hill and valley, their origin, growth, and final destiny, is one full of interest to all who attempt to read the story locked in the land forms and river valleys. The everlasting hills which have apparently stood unmoved and unaltered during the lifetime of the native resident and his fathers before him, appear to him constant features of this old earth.

But in a duration of time geologically short, great changes have occurred in these seeming permanent land forms, and rapid changes are taking place today before the eyes of man if only those eyes are trained to see aright and are not blind to the forces of nature. Everything changes and grows old, even these so-called everlasting hills; and all conform to the universal law of nature—adjustment to environment, or to surrounding conditions. This law holds in the inorganic world of rock and cliff, as well as in the world of organisms.

The engraving tools of frost, heat and cold, rain, running water, are making great waste of land material which is started on its almost ceaseless march, short or long, to the sea, the final resting place for such materials.

In order more clearly to understand the results of all this work of atmospheric and aqueous agencies, let imagination picture the growth of a typical land area. The sediments accumulating below the waters of the sea become cemented together and consolidated into rock masses which by earth movements are raised into dry land, a smooth upland plain or plateau with its minor depressions and irregularities. The rains descend upon this land and the water gathers in the depressions and flows off in small rivulets. These small streams flow together and form larger ones and pursue their paths seaward. With increase in volume the creeks become rivers in deeper channels. The streams

follow nearly parallel courses separated by low divides with lakes in the depressions.

With the cutting action of the silt laden waters, the channels are carved deeper. The little tributaries are enlarged, cutting backward into the divides until the land area is covered with a branching net work of streams like the branches and twigs of a tree. Side by side with the waste of the land through erosion by water, the atmospheric agencies are at work widening the upper portions of the valleys which thereby lose their trench-like character and approach V-shaped valleys.

As these young streams cut their channels downward, obstructions may be met, a mass of hard rock or other material, and the run or creek bends around it, or the inequality of the original surface may deflect its course, so that the path seaward is not the straight and narrow one, but a winding course. The head of the stream and every tributary are cutting backward in a course more or less irregular, so that the final course of the stream is meandering.

As the erosive work goes on day and night, year after year, century upon century, the streams on the two sides of the divide approach each other finally cutting away the divide into a series of hills which are further attacked by the tireless energy of water and air until they also are removed wholly or in part. There remains a smooth plain no longer upland but near the level of the sea, and the land is said to be at *base-level,* and the cycle is completed from sea plain through upland plain to coastal plain. This plain is not the level area it was in the beginning of its history, for here and there are the low hills left between the streams, but it is *almost* a plain and so has been named a *peneplain (pene*-almost).

Earth's forces may again raise the low peneplain to an upland, and the work of erosion begins a second time following the same line of development. According to the studies of geologists, the Appalachian area was apparently brought to a peneplain in Cretaceous time, and re-elevated to be reduced to a second peneplain in the Tertiary period. It was elevated again at the close of that period, and at the present time the work is progressing toward the reduction to a third peneplain.

The rivers on these plains pass through a cycle of similar development to that of the land forms. By analogy, this cycle is compared with the life history of organisms passing from the period of infancy through adolescence, maturity, to old age and death.

In the earlier life of the stream as it cuts its way downward, the valley slope is steep. Erosion is rapid through the softer rocks while the more resistant layers withstand the cutting force and remain for a time as projecting layers over which the water pours in rapids or falls, and the river is in its period of infancy passing into the period of adolescence. The river is now eroding its channel deeper and deeper, and but little from side to to side.

As the valley floor approaches more nearly the level of its outlet, the current becomes less swift, the projecting ledges of the falls are brought to the general grade of the stream. The river cannot now cut its channel downward as rapidly as before and it increases the erosion laterally widening the valley. Its load of sediment before carried outward in the swifter current is now dropped in large part and fills the lower part of the channel spreading out in flood plains. Over these plains the river may take a meandering course, winding from side to side, cutting in one bank and filling on the other. The river now carries its maximum load of sediment and performs its greatest work of erosion, so it is said to be in the *maturity* of its life.

When the river valley is graded to a level with the sea, reaching its base level, the current is sluggish or absent, the sediment falls, obstructing the channel, and the river is no longer able to perform its work. It has reached the period of *old age,* and settles down to a period of quiescence.

While the lower portions of a great river may reach this period, its head waters may still be pushing their way backward, cutting into the divides further and further. A single stream may thus be in various periods of the life cycle from source to mouth, a complex river made up of parts. The divides are deeply dissected, and by the more rapid cutting of larger or swifter streams on one side, may migrate toward the weaker streams. If this action goes far enough the divide may be finally cut through in places, tapping the headwaters of the stream on the opposite side, which may flow through the break and the waters pass to the

sea by the way of the faster working stream. The remnants of the old streams still pursuing their former paths are spoken of as *be-headed streams.*

When the peneplain is raised to the upland with its mature meandering rivers, these will again take up the work of erosion with the activity of a renewed youth and cut the gorges with their inherited winding courses, thus giving a youthful river with many characteristics of the inherited maturity.

The course of the river and land history as outlined above may be interrupted by forces so far removed from the ordinary that they may almost be called geological accidents. Thus in the Quaternary period of the history of the North American continent, the northern seas were covered with an onward moving ice sheet of great areal extent and thickness. As this mass of ice moved southward across the courses of the rivers, they were often changed in direction and character, bringing still other problems to solve. The wall of ice if thrown across the downward course of the river, would pond or dam back the waters causing them to overflow at some low point in the enclosing valley walls. By further erosion of this low point, a new course for the river would be established which might be retained when the ice barrier was removed, or it might then return to its old course.

With the melting of the large mass of ice, there would be added a silt laden body of water which might overload the stream far beyond its capacity for waste removal, and then fill up its channel wholly or in part. The river would then follow a new path which might be over the old one or to one side and thus be *superimposed* on its former bed. It is this unusual geological force that has greatly altered the river history of the area under consideration in this report. The terminus of the northern glacier was not many miles (10 to 15) north of the northern portion of the Pan Handle, and its indirect effects of floods of water extended far to the south of this area.

If the map of the Pan Handle is examined with reference to its drainage system, a marked contrast will be noticed between the streams in the northern county and the southern one. Ohio county and southern Brooke are characterized by the irregular branching network of streams, the divides are irregular, and the streams with the exception of the larger creeks have a general southward

direction on the longer slopes of the divide, thus conforming to the dip of the rocks.

In the northern portion of Brooke county and in Hancock, the irregular network is absent, and the streams flow in more nearly parallel paths, but still with the longer branches flowing southward with the dip.

Further, the larger streams in the whole area show a strong tendency to northwest courses and have a very winding channel. In order to properly understand the river history of the area, it is necessary to pass backward in time to the period before the glacier invasion and attempt to reconstruct from the topographical clues, the pre-glacial drainage.

America's best glacial geologists have studied this problem and from their investigations have delineated the courses of the rivers of that far away time. It thus found that the drainage conditions were very different. There was no Ohio river flowing south-westward to join the "Father of Waters," though rivers occupied a portion of the valley now drained by the Ohio. Near Moundsville, Leverett found the evidence of a former divide, the waters flowing south from there to about the location of Point Pleasant, then turning north-westward across Ohio in what Professor Tight has named the Marietta river. From the Moundsville divide there flowed northward the old Ohio to near the mouth of the Beaver, where it emptied into a river flowing north to the site of Lake Erie, a river which has been named the Pittsburg.

The tributary streams across the Pan Handle had a similar north direction, flowing northwest to join the old Ohio. The terraces of this old river are still visible especially in the northern part of the Pan Handle and adjacent portions of Ohio and Pennsylvania.

When the great ice wall crossed the paths of the Pittsburg and other northward flowing streams, their waters were held back before the ice obstruction, filling their valleys which stood at much higher level than at the present. The waters spread outward on their higher slopes forming some of the higher river terraces. The rivers finally cut their way through low portions of the divide taking a southern course. The Ohio cut through the divide near Moundsville, joining the Marietta river, whose northern outlet was also cut off, and the present Ohio river came into exist-

ence cutting through the divides further south, probably following closely its present path. The Monongahela tributary of the Pittsburg river may have cut through near Salem and passed south-westward for a short time. When the ice sheet finally retreated, the Monongahela regained its former course, but the Ohio remained in its new channel.

In this early history of the Ohio river the water flowed at a much higher level than now. The present channel has been largely cut down since the Glacial period. The old terraces left here and there along its banks mark the elevation of the channel in its different stages. These terraces reach 1000 and 1050 feet above the sea near Wheeling, while the present river is about 610 feet above the mean tide. At the mouth of the Little Beaver river, opposite the northern edge of the Pan Handle, the terraces are 870 to 965 feet. According to Leverett, the river cut down to the 930 foot level near Wellsburg before the course was reversed to the south. The channel has been cut from 930 feet to 660 feet since the Glacial period. There is also evidence that it cut deeper for the rock floor is about 30 feet below the present river floor, and has been filled with sediments. There still remain in this area as monuments of this ice invasion, the gravel and boulder terraces.

The tributary streams of the Ohio in the Pan Handle area for the most part preserve their ancient northwest trend, but a number of them have changed their courses to the south near the mouths of the streams, giving the peculiar turns noticed in such creeks as; Wheeling, Short, Cross, Harmon, Hardin, and Tomlinson.

The larger streams are enclosed by high valley walls and flow in gorges with sloping sides in part. In these gorges the water meanders from side to side. They are not at base level, but descend rapidly to the Ohio. Wheeling creek has a fall of eight feet to the mile in the twelve miles of its lower course from the mouth of Grandstaff run to the Ohio. The air line distance is only six miles. Buffalo creek from Bethany to Wellsburg flows through a winding course of fourteen miles with a fall of 150 feet, or nearly eleven feet to the mile. The air line distance is only five miles. Cross creek in a distance of seven and one-half miles falls 127 feet, or 17 feet to the mile, and the air

line distance is only five miles. Harmon creek falls 169 feet in seven miles, or 24 feet to the mile, and the air line distance is four and a half miles. Kings creek falls 140 feet in six miles, or 23 feet to the mile. Tomlinson's run falls 440 feet in eight miles and a half, or 52 feet to the mile, with a few meanders.

The fall of the streams thus increases as traced north from 8 feet to the mile, to 11, 17, 24, 23, and 52 feet, while the ratio of water distance to air line distance along the valleys decreases, or in other words the meandering of the streams is less.

The fall of these winding streams at the south shows that the meanders are not due to their approach to base level, for they are in the youthful stage of the river cycle, and they possess this character of maturity by inheritance. In the pre-glacial period they probably cut their channels nearly to base level of the northward flowing Ohio, and then started on their winding courses. With the later downward cutting of the Ohio, the tributary streams were endowed with new life and energy.

The smaller tributary creeks have the characters of youth, but they have advanced their work rapidly in the soft shales and rocks of the Dunkard and Monongahela series, reaching the harder intercalated limestones which form projecting ledges over which the water falls. Scarcely a stream in the area can be found without these falls or small rapids. Even the larger creeks abound in water falls over the hard limestones.

After passing north of Buffalo creek, the prominent winding streams are absent and the drainage system lacks the irregular network arrangement, giving evidence of a younger period of stream history. This is not due to their formation at a later time in geological history, for these streams with their northwest trend give evidence of existence during pre-glacial time, the same as further south. The streams are, however, small in volume due to the decrease in size of their drainage areas. The distance is shorter at the north between the Ohio and Monongahela rivers, and the divides are so located as to give short courses to the Ohio. With decreased volume of water, the erosion would be much slower both in preglacial and post-glacial time.

The difference in character of the stream valleys north and south in this area is not due entirely to the structure of the rock masses, though the northern streams are in lower measures than

Plate II.—The "S" Bridge on the National Road East of Elm Grove, Ohio County.

those south. The hard strata at the north are sandstone, and at the south mainly limestone. The latter through solution and erosion would be removed more rapidly than the heavy sandstone at the north. This arrangement of more resistant rock masses northward and less resistant in the southern part of the area, explains in part the difference in the valleys of the two areas. A greater cause of these changes in character is found in the decreased size of the drainage basins as followed northward, with resultant decrease in volume of water.

DESCRIPTION OF THE DRAINAGE BASINS.

Wheeling Creek.

Wheeling creek rises in the western part of Greene county, Pennsylvania, and flows north-westward through the north-eastern part of Marshall county and the south-western part of Ohio county, emptying into the Ohio river at Wheeling. Its channel is very crooked, winding back and forth and making a complete bend on itself at the east side of the city of Wheeling.

At Elm Grove, in Ohio county, it receives the largest tributary stream, Middle Wheeling creek, which is joined by Little Wheeling creek one mile and a half east, near Triadelphia. Little Wheeling creek rises near West Alexander, just over the state line in Pennsylvania, and flows southeast to Elm Grove. Middle Wheeling creek rises in the western part of Washington county, and flows almost east in a winding channel.

The drainage basin of Wheeling creek and its tributaries, in western Washington, eastern Ohio and Marshall counties, covers 192 square miles, being nearly as large as the total drainage areas of all the other creeks of the district described.

Near the mouth of Wheeling creek there is evidence of readjustment of the course of the stream in the big bend around the Wheeling peninsula. Just north of the city on the reservoir hill there is a break in the hill, through which the creek probably flowed at this high level when the Ohio had its northern course. As the Ohio cut its channel down and flowed to the south, the creek was unable to continue in its old path and turned to the south, following around Wheeling hill to join the river below.

Farther back near Mont de Chantal, the creek has apparently followed three different paths in its downward cutting, one to the north, one to the south, finally selecting the middle course. The difference in level of these three paths is only 40 feet, and at high water the stream might take any one of these three channels.

The tributary streams from the north into Wheeling, Middle, and Little Wheeling creeks follow nearly parallel courses to the south. The divide between Wheeling and Buffalo creeks is a winding ridge trending approximately east and west and located near the northern part of Ohio county. Nearly the entire county of Ohio is thus drained by Wheeling creek and its tributaries, with the exception of the north-western part drained by Short creek, and the north-eastern corner drained into Buffalo creek.

The most important tributaries of the Wheeling creek system from the north are, Peters, Roney's Point, Dixon, Battle, and McGraw runs, while from the south, Point run passes into Little Wheeling. Flowing into Middle Wheeling creek from the north are, Marlow, Orr's, Hall, Coulter, and Todds runs; while from the south are Gillespie and Ladley runs. Wheeling creek receives also from the north Woods run, formed by the union of Long and Waddle's runs, and Carter run. The tributary streams from the south into Wheeling creek and its two main branches, travel for the most part short paths with rapid descent down the steep south banks, and the water falls from ledge to ledge of the hard resistant layers.

Short Creek.

The north-western portion of Ohio county is drained by Short creek which rises in the north central part of the county and flows northwest, emptying into the Ohio at the Brooke county line. Its main branch is the North Fork, rising in the high hills near West Liberty, in the northern part of the county. The main tributaries at the north are Waddle's run, and to North Fork, Huff run. From the south it receives a number of small streams, the largest being Souttell run. Short creek is not so winding as Wheeling creek, and its drainage area is much smaller, being about 22 square miles. The creek makes one sharp bend two miles and a half from its mouth, which shows a resemblance to Wheeling and Buffalo creeks. Near its mouth

the creek bends to the southwest, but it probably followed the path to the northwest in a former high level period. This abandoned path is now occupied by a small creek flowing to the north.

Buffalo Creek.

Buffalo creek carries the surface waters of the southern part of Brooke and the north-eastern corner of Ohio county. This creek rises in the central part of Washington county and flows northwest to the Ohio just below Wellsburg. Its path is very winding so that it resembles Wheeling creek, but has a smaller drainage basin of about 96 square miles. This area is larger than that of the streams further north.

The meanders of Buffalo creek are sharp and large, bending in some cases a mile from the direct course. Like Wheeling creek, these bends are enclosed by rock walls and represent an inherited character of maturity. They were probably formed at high level when this stream also approached the base level of the northward flowing Ohio. Buffalo creek is one of the few streams of the area which joins the Ohio with a northward direction. The mouth of the stream has not been deflected to the south with the reverse course of the Ohio.

Buffalo creek has encroached on the Short creek divide, giving longer north flowing streams than usually found in the area, but its longest tributary streams come from the north with a single exception. This exception is found in the eastern part of Brooke and Ohio counties, where Castleman creek reaches six miles south, making a narrow divide on Little Wheeling creek. This small stream flows in a fairly straight channel to the north, and has a number of tributary streams, the largest being Long's run. In a former time it was probably an important fork of Buffalo.

The important tributaries of Buffalo creek from the south are Greens, Kimlin, Grog, Hukill, Hoglan, Scott, and Castleman runs. From the north it receives Painter (Panther), Titt, Pierce, Mingo, and Wells run in West Virginia, and other streams in Pennsylvania.

Cross Creek.

Cross creek enters the Pan Handle area from Washington county, and follows a course almost due west, but with a winding

channel. It is also similar to the other creeks of the area in having short branches on the south and longer tributaries at the north. The important runs from the north are, Bosley, Ebenezer, Parmar, and a branch un-named on the maps, with Potrock creek from the south. Its drainage area is about 40 square miles.

Harmon Run.

Harmon run, with its headwaters in Washington county, flows northwest to New Cumberland Junction, then turns to the southwest for two miles to the Ohio. Its tributary streams are longer from the north than from the south, but the difference is not as marked as in the streams further south.

Near its mouth is a large rock island mass enclosed by the Ohio river on the west and a deserted channel at the east. This island is two miles and a half long and a mile wide, rising to a height of 1060 feet above the sea level and 450 feet above the present river level, with an almost level top. The channel at the east, known as Holliday's Cove, represents an old channel but its origin is in some doubt. A possible theory of origin is suggested by the comparison of Harmon creek with the larger streams at the south. The normal course of this river in preglacial time would be northwest through the Cove, reaching the Ohio at the north end of the Cove. There possibly was a small stream at the south end of the Cove, flowing southwest and cutting its way backward toward Harmon creek. When the waters of the northward flowing Ohio were held back by the wall of ice, they would fill the Cove valley, breaking through the little stream valley to the south. At this time the waters of the Ohio probably filled both channels with the island between. When the divide near Moundsville was cut through, the direction of the Ohio was changed to south, and the Cove and present river valleys were deepened. As the Ohio cut its channel deeper, it abandoned the east channel leaving deposits of sand and gravel which closed the former outlet of Harmon creek and caused it to flow southwest in the present channel. The abandonment of this east channel by the river did not occur at the close of its glacial history, but in comparatively recent times, as is shown by the depth of the Cove channel. Just why it abandoned the east chan-

nel is hard to determine, but at some flood period it may have left the obstruction at the entrance.

Kings Creek.

Kings creek is another winding stream with a decided northwest course near its mouth. Its longest tributary is the North Fork which flows from Beaver county southwest. The characters and history of Kings creek are similar to the streams further south.

Hardin and Tomlinson Runs.

Hardin run rises in the eastern part of Hancock county and reaches the Ohio at New Cumberland. Its headwaters are separated from the North Fork of Kings creek by a narrow divide and the stream flows in a nearly straight channel. It has a rapid fall and is a young type of stream, possibly post-glacial in origin.

Tomlinson run north of New Cumberland drains an area of 35 square miles and is formed by the union of the North and South forks, which rise in Beaver county. The run now empties into the Ohio near Moscow, flowing southeast from a point one mile and a fourth back, where it is joined by Whiteoak run. Whiteoak run is separated from Congo run at the north by a low divide and probably represents the course of Tomlinson run in preglacial time, when its outlet was to the northwest at Congo. In later time the small tributary to the south flowing Ohio cut its way back through the divide and tapped the creek at the present mouth of Whiteoak run, leaving Congo run as a beheaded stream. The streams at the northern edge of the Pan Handle flow north to the Ohio in nearly straight channels, but with rapid fall.

TOPOGRAPHY OF THE LAND AREA.

The Pan Handle area is a highly dissected plain or plateau of 1200 feet elevation. This plateau now has a very irregular outline on account of the water erosion, and the streams flow in deeply cut valleys. Numerous hills and ridges of 1300 to 1400 feet elevation remain and are capped by more resistant rock strata, sandstone and hard limestone.

The Ohio river has cut a deep gorge separating the states of Ohio and West Virginia. The rocks correspond in character and level on both sides of this gorge. The river bluffs are usually steep, often perpendicular, but on reaching their top the general surface of the land is rolling except for the deep trenches of the creeks and runs. The inequalities of the surface are due to the underlying rocks, the softer portions being eroded and the more resistant layers forming bluffs and hills.

The present flood plain of the river is represented by a number of islands and bars, such as Wheeling, Brown's, and Babb's islands; also by the rich bottom lands along the shore which are often narrow strips and again widen out now on one bank then on the other.

The River Terraces.

Along the Ohio river in the Pan Handle area is a series of terraces especially well defined north of Short creek. These long, narrow, level stretches of land, one above the other, and separated by steep bluffs, are conspicuous features in the topography. Chester and New Cumberland are built on two of these terraces, forming an upper and lower town, while Wellsburg, Follansbee and Congo are built on a single terrace. Wheeling is built on two terraces, but the bluff between the two has been graded so as to give a gradual slope to the lower one.

These river terraces were first described in detail by Dr. I. C. White[1] in 1876 in Beaver county, Pa., adjoining the northern portion of the Pan Handle. Dr. White found in this area five terraces which he located as follows:

Fifth terrace	280 to 300	feet	above	the	river.
Fourth terrace	200 to 220	"	"	"	"
Third terrace	120 to 130	"	"	"	"
Second terrace	60 to 80	"	"	"	"
First terrace	30 to 40	"	"	"	"

The *first terrace* is composed of coarse and fine sand, fine gravel, and clay. It represents the flood plain of the river and includes the various islands and bars of the stream. Some of these islands in this area have received definite names as, Babb's,

1. 2nd Geol. Survey of Penn. Report Q. p. 10.

Baker, Cluster, Black's, Brown's, Beach Bottom, Pike, Upper and Lower Twin, Wheeling, and Boggs. It forms the broad flat terrace 30 to 40 feet above the river near Congo, Arroyo, Moscow, the old valley floor near New Cumberland and Wheeling Junctions, the terrace at Follansbee (Mahan), Wellsburg, Beach Bottom, Wilson, Glenn's run, and lower portion of Wheeling. The Pennsylvania railroad track from Wheeling north is built on this terrace. Near Arroyo the soil of this terrace is especially adapted for fruit trees and large orchards are found here. Further south, near Wheeling, the terrace is covered with extensive truck farms. During high water stages of the river this flood plain is under water, occasionally being completely covered.

The *second terrace* consists of coarse material, coarse gravel, rounded boulders, rock fragments, mixed with fine sand and gravel. This material is worked at a number of places along the railroad for ballast. A very good quality of gravel in large deposits is found south of Arroyo and near Beach Bottom and is worked in a bank 20 to 30 feet high.

This terrace forms the upper part of the towns of Chester and New Cumberland. It is the upper terrace in Wheeling at the new postoffice building, Board of Trade building, etc. At Chester it is 36 feet above the lower terrace, and 45 at New Cumberland.

The *third terrace* is composed of coarse and fine gravel and is 40 feet above the second at Chester, and 90 feet at New Cumberland. It does not appear to be well defined southward except in places, as east of Wheeling, near Short creek, and here and there near Wheeling.

According to Dr. I. C. White[1] the fourth terrace in Beaver county possibly represents the upper limit to which the valley of the Ohio was filled by the waters of the melting ice after the Glacial period. From his studies of these terraces he concludes: "It cannot be certainly known, however, that the old valleys were refilled to a higher level than the top of the third terrace, for here the metamorphic boulders apparently cease, and a rocky escarpment leads up to the fourth terrace at every point where the fourth is seen.

1. loc. cit. p. 13.

"Not so with the escarpment of the second and third terraces; for these, although they are quite steep, are cut down through the boulder bed itself. At Beaver, several wells commencing at the top of the third terrace have been sunk down to the level of the Ohio, but no solid rock was found in any of them."

THE OHIO RIVER.

The Ohio river bounds the Pan Handle area at the north and west making nearly a right angled turn at the north-western corner of the area. Its entire length is 967 miles, and its length along the Pan Handle from the Beaver county line to below Benwood is 55 miles with a fall of nine inches to the mile, and its width varies from 900 to 1200 feet. Its geological history and its terraces have been described.

The main divide between the water flowing west from Pennsylvania and east into the Monongahela is found in the west central part of Washington and Greene counties, Pennsylvania. The divide at the south passing west of the town of Washington is quite regular, but at the north is irregular and zigzag. All the larger streams of the Pan Handle area have sources in Washington and Greene counties, Pennsylvania.

The River Channel.

By act of Congress, June 3, 1896, the sum of $25,000 was appropriated for a survey of the Ohio river from Marietta to Pittsburg. This survey was made under the direction of Major W. H. Bixby, Corps of Engineers, who made his report December 28, 1898. This report was published by the House of Representatives as document No. 122 of Fifty-fifth Congress (third session), January 7, 1899, and forms the basis of the following discussion:

The floor of the main channel of the Ohio river is very irregular, giving a depth of low water varying from less than 2 feet to 31. Where the river enters the Pan Handle (low water 646.5) the channel reaches a depth of 14 feet, while at Line Island it is only 2 feet. At the location of dam No. 8, two miles below East Liverpool, there is a depression of 25.6 feet, and the depth of water will be increased 10.7 feet. Opposite New Cumberland the channel is 3 feet deep at low water, and two miles

and a half below town is 17.8 feet. Three miles and a half below New Cumberland is the location made for dam No. 9, where depth of water at low water stage is 13 feet, which will be increased by the dam 11.5 feet. The distance between dams 8 and 9 is 13.5 miles with a fall of 7.8 feet.

Dam No. 10 is to be located 5 2-3 miles below No. 9, and 2¼ miles above Steubenville, where the channel is 13 feet deep at low water and will be raised 12.3 feet. Just above this location is the deepest place in the river channel between the mouth of Little Beaver river and Marietta, reaching 31.2 feet below low water. Eleven miles below No. 10 is No. 11, two miles and a half below Wellsburg where the channel is 6.4 feet deep and will be raised 12.1 feet. This dam is now under construction with the concrete masonry of the locks nearly completed. The distance between Nos. 8 and 11 is 30 miles, with a fall of 23.2 feet or .7 foot to the mile.

Dam No. 12 is to be located 10½ miles below No. 11 and three-fourths mile above Martins Ferry. The present depth of water here is 5.2 feet and will be raised to 11.5. Dam No. 13 is now under construction 9 miles below No. 12 and one and two-third miles below the B. & O. railroad bridge at Benwood Junction. The depth of water at low water stage is 3.9 feet and will be raised to 16.7.

The locks at dams 8, 12 and 13 will be on the West Virginia side of the river, while 9, 10 and 11 will be on the Ohio side. These locks will be at least 600 feet long, 110 feet wide, with 6 feet navigable water in lower pool and 7.6 feet lift. The total cost of one of these dams and locks was estimated in this preliminary survey at $850,000.

Cross Sections of the River.

In the preliminary work on the location of dams 8, 11, 13, borings were made across the channel to determine the amount of filling in the old river valley, or depth to the rock floor. These records have been kindly furnished by Major Geo. A. Zinn, engineer in charge of Ohio river work.

At the East Liverpool dam (No. 8) the first terrace of the river, 40 feet high, is composed of gravel and sand which extends 32.9 feet below low water of the river. At this depth is

found a blue slate. The average distance below low water to bed rock at this place is 32.5 feet and the rock floor appears to be nearly horizontal.

Below Wellsburg (No. 11), the lower terrace is 40 feet above the river composed of sand and gravel which extends to 29 feet below low water to a sandstone bed rock. This rock is also about horizontal and 32.5 feet below low water. The water increased in depth from 2.2 feet on West Virginia side to 5.8 on the other side. The rock floor at this dam is 125 feet below the Ames fossiliferous limestone which crops in the hills above, and may represent the Buffalo sandstone which in other sections is found at nearly this interval.

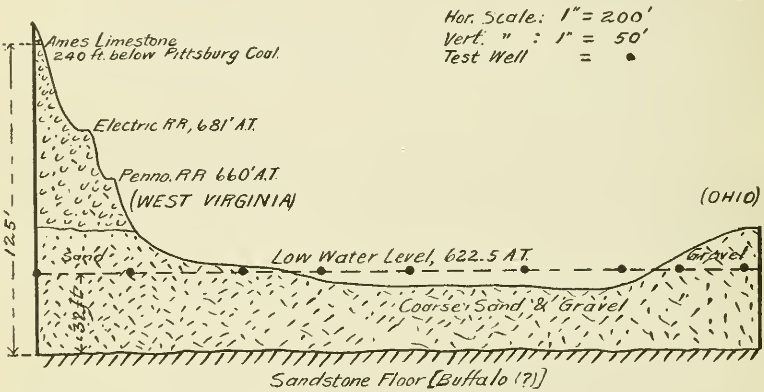

Fig. 1.
Cross Section of Ohio River Channel at Dam 11, Below Wellsburg.

At the dam below Benwood Junction (No. 13), the average thickness of sand and gravel fill to the rock floor is 30 feet, but the rock floor is cut down to 49 feet near the West Virginia side. The average distance from the low water level of the river to the rock floor is 34 feet, being now filled with sand and fine gravel for 32 feet. The navigable channel of the river is cut in this sand fill to varying depths giving a very irregular profile of the channel floor.

Maximum and Minimum River Stages at Wheeling.

The following data on maximum and minimum river stages at Wheeling have been furnished by Mr. Alex. McAshley, local forecaster of the United States Weather Bureau at Pittsburg:

These observations, extending over a period of 25 years, show the highest recorded stage of the river at Wheeling, 46.5 feet, on February 8, 1884; the next highest was 44.6 feet on February 19, 1891. The maximum stages in the different years are found in the months of January, February, March, April, though it has been reached once each in May, June, August and November. The river reached a stage of over 40 feet in six years out of the 25, and over 30 feet in 11 years. The lowest maximum recorded was 1.4 on October, 1892, and it was four feet or under in 21 months of the 25 years.

The lowest stage of water in the 25 years was 0.3 on August 27, 28, 1893. It was 0.2 September 8, 1894. It has been less than one foot 12 months in the 25 years, and these months were in seven years during August, September, October, and November. The highest minimum recorded was 14 feet in February, 1891.

The average stages during the 25 years show the average maximum stage in March, and the lowest maximum in September. The average minimum stage was in September and the highest minimum in April.

MAXIMUM RIVER STAGES AT WHEELING, 1882-1906.

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1882	....	....	....	....	21.2	18.0	15.8	9.3	10.0	9.8	5.7	9.8
1883	17.0	35.5	10.3	22.5	....	....	....	....	....	....	....	....
1884	....	46.5	30.5	17.6	9.8	11.0	10.5	9.8	3.1	5.6	5.8	16.5
1885	32.8	10.8	15.3	24.3	9.3	12.3	7.0	15.9	9.8	11.8	9.6	16.8
1886	29.3	31.0	21.5	32.0	15.0	12.0	6.5	8.3	5.8	6.6	22.0	16.5
1887	24.3	33.8	24.0	14.8	15.5	16.0	4.6	3.2	2.0	....	5.0	5.8
1888	29.8	16.0	19.6	22.0	11.0	8.6	27.1	32.2	11.0	15.5	18.0	16.0
1889	19.0	23.0	17.1	21.0	15.2	28.9	13.6	7.8	4.0	11.0	17.4	19.5
1890	27.8	24.9	32.5	27.2	27.5	10.9	7.0	10.0	24.7	22.9	17.6	14.8
1891	32.9	44.6	19.0	20.9	6.0	15.8	13.0	11.9	7.3	3.0	15.0	17.8
1892	29.0	19.0	23.0	16.0	18.0	23.3	9.5	5.0	3.5	1.4	6.7	11.0
1893	....	32.1	24.8	23.9	31.5	7.0	6.7	4.0	6.9	7.5	9.8	20.5
1894	13.0	22.5	19.3	16.1	28.9	10.9	3.9	2.4	14.0	3.6	7.2	12.5
1895	36.0	7.0	22.2	26.9	6.0	4.1	5.5	3.5	3.3	1.9	9.6	18.5
1896	14.9	19.9	28.4	29.9	9.6	11.3	27.3	22.1	5.0	15.6	11.7	15.9
1897	9.9	37.0	28.0	20.7	18.8	7.9	13.8	7.8	3.0	2.1	13.6	18.9
1898	27.5	21.4	43.9	23.0	16.9	9.9	5.5	17.5	4.4	18.7	21.1	22.8
1899	24.3	20.6	28.2	21.3	22.6	9.8	8.4	6.2	5.9	2.8	7.3	17.7
1900	23.3	25.0	24.9	11.0	6.6	9.5	8.3	6.5	3.0	3.2	34.3	18.0
1901	18.0	8.4	29.0	41.3	25.0	20.5	7.9	7.7	9.0	4.4	14.6	33.9
1902	21.6	17.7	42.0	32.9	8.6	7.9	24.0	11.9	2.6	10.5	11.0	25.6
1903	25.5	34.6	40.2	19.5	8.1	14.7	12.7	11.9	11.7	10.3	16.3	9.9
1904	34.2	26.3	38.5	33.9	18.2	17.0	14.2	5.1	3.4	4.9	3.9	16.4
1905	17.4	17.6	42.9	14.4	14.4	16.3	9.9	13.4	10.7	15.9	12.6	31.6
1906	24.3	8.6	25.9	26.6	9.6	15.4	4.9	15.3	4.7	9.0	18.0	....
Average...	24.1	24.3	27.1	23.3	15.5	13.3	11.1	10.1	7.1	8.1	12.8	17.6

MINIMUM RIVER STAGES AT WHEELING 1882-1906.

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1882	....	....	....	....	6.2	6.8	3.4	3.2	3.7	3.0	3.2	3.5
1883	4.3	10.0	7.5	10.0	....	....	....	....	....	....	....	....
1884	....	10.2	7.0	6.7	5.5	4.3	2.8	2.6	1.6	1.7	2.5	3.8
1885	5.2	4.8	3.8	9.5	5.3	3.8	2.3	3.3	2.9	1.8	5.7	6.0
1886	6.6	5.5	5.2	5.7	4.8	2.8	2.1	2.3	1.5	1.3	1.5	5.5
1887	5.1	13.3	6.2	5.8	4.6	2.6	1.0	1.3	1.0	....	1.1	2.7
1888	4.1	7.6	7.2	6.1	4.9	1.9	2.8	2.0	3.2	2.6	7.4	7.0
1889	7.4	5.5	6.4	6.5	6.5	7.9	4.4	2.0	0.9	2.6	6.9	8.1
1890	8.6	9.8	8.0	5.9	9.9	5.0	1.8	1.9	4.0	7.0	7.0	3.9
1891	7.0	14.0	9.0	5.5	2.6	4.9	4.0	2.3	1.2	0.9	1.7	6.3
1892	6.3	6.8	6.0	6.4	5.8	5.6	2.7	1.7	1.2	0.9	0.9	5.0
1893	....	8.5	8.4	7.3	7.1	3.0	1.5	0.3	1.2	1.7	2.7	6.9
1894	5.9	6.9	6.9	6.8	4.4	3.2	1.3	1.3	0.2	2.1	3.1	4.5
1895	4.0	3.9	9.3	5.7	3.9	1.7	2.3	1.2	1.3	0.6	0.8	2.9
1896	3.9	5.9	6.7	7.8	3.8	4.3	4.5	3.1	2.3	5.0	4.8	4.2
1897	5.4	9.5	8.9	7.0	4.9	3.6	2.8	3.0	0.9	0.4	0.5	6.2
1898	6.3	5.8	7.0	7.1	7.2	3.7	1.7	4.3	1.5	1.6	5.6	4.9
1899	7.6	5.1	9.7	6.6	5.8	4.0	2.8	1.3	1.0	1.1	1.8	4.0
1900	7.7	4.9	7.7	7.0	3.6	3.3	2.7	1.2	0.3	0.3	1.6	4.9
1901	4.4	4.5	6.3	11.3	6.7	7.3	2.2	1.7	3.2	1.9	1.5	7.2
1902	4.0	4.8	7.9	6.3	4.8	3.8	6.0	2.4	1.1	2.9	2.4	6.8
1903	6.9	7.8	10.0	6.9	2.7	3.4	3.9	2.4	1.8	2.2	2.9	3.0
1904	4.9	4.0	9.3	7.3	5.6	4.9	3.6	1.6	1.3	2.6	1.3	1.4
1905	3.1	4.4	13.4	7.3	4.9	5.0	4.3	4.5	2.8	2.8	5.0	5.9
1906	7.4	4.2	6.1	8.3	4.3	4.1	2.1	2.8	2.7	2.9	4.5	....
Average...	5.8	5.7	6.8	7.1	5.2	4.2	2.8	2.1	1.7	2.1	3.1	4.9

Ohio River Flood Records.

The following table of Ohio river flood records is often given, but the authority for the figures is not known to the writer, and they do not agree exactly with the records given above:

Date.	Pittsburg.	Wheeling.	Diff.
Nov. 10, 1810..........................	32.0	48.0	16.0
Feb. 10, 1832..........................	35.0	48.1	13.1
April 20, 1852..........................	31.9	48.0	16.1
April 13, 1860..........................	26.7	43.0	16.5
Sept. 30, 1861..........................	30.0	44.2	14.2
April 23, 1862..........................	27.9	37.0	9.1
March 19, 1865..........................	31.4	41.0	9.6
Dec. 15, 1873..........................	25.6	40.8	15.2
Jan. 9, 1874..........................	22.4	38.8	16.4
Dec. 12, 1878..........................	24.9	34.9	10.0
June 21, 1881..........................	25.6	40.9	15.3
Feb. 19, 1883..........................	25.8	39.7	13.9
Feb. 7, 1884..........................	33.6	52.4	18.8
Feb. 18, 1891..........................	31.3	44.1	13.8
Jan. 8, 1895..........................	25.9	36.2	10.5
Feb. 24, 1897..........................	24.5	37.1	12.6
March 24, 1898..........................	28.5	44.6	16.1
April 22, 1901..........................	28.0	41.9	13.9
March 2, 1902..........................	32.4	43.3	10.9
March 2, 1903..........................	29.0	40.3	11.3
Jan. 24, 1904..........................	30.1	44.2	14.1
March 4, 1904..........................	29.1	39.3	10.2
March 22, 1905..........................	28.8	42.7	13.9

PART II.

The Geology of the Pan Handle Counties.

INTRODUCTION.

GENERAL GEOLOGY OF THE PAN HANDLE AREA.

The rocks of the earth's surface have been classified by geologists in a series of divisions based for the most part on the life of past ages as preserved in a fossil state in these rocks. The main divisions of the geological column so constructed on these characters are the following:

Cenozoic—Recent life forms.

Mesozoic—Less recent forms.

Paleozoic—Oldest forms of life.

Archaean—Crystalline rocks with no undisputed evidence of life.

The geology of the state of West Virginia is included in the Paleozoic division and the greater portion of the State consists of rocks belonging to one subdivision of this era, the Carboniferous. The subdivisions of the Paleozoic are:

Carboniferous, { *Upper.* / *Lower.* }
Devonian,
Silurian,
Cambrian.

The subdivisions of these periods as found in West Virginia are given in the following table. The geology of the northern Pan Handle counties is included wholly in the Upper Carboniferous, and the exposed rocks are above the Pottsville series.

TABLE OF GEOLOGICAL FORMATIONS IN WEST VIRGINIA.

UPPER CARBONIFEROUS.

Dunkard or Permo—Carboniferous series (1100 to 1200 feet).

Monongahela Series—(260 to 400 feet).

Conemaugh Series—(600 feet).

Allegheny Series—(225 to 600 feet).

POTTSVILLE SERIES.

Northern Section (250-300 feet).	*New River Section* (1,200-2,000 feet).
Homewood Sandstone.	Nuttall Sandstone.
Mount Savage Fire Clay.	Sewell Coal.
Mount Savage Coal.	Welch Coal.
Upper Mercer Coal.	Raleigh Sandstone.
Lower Mercer Coal.	Beckley Coal.
Upper Connoquenessing Sandstone.	Quinnimont Coal.
	Horsepen Coals.
Quakertown Coal.	Pocahontas Coals (Nos. 4 to 1).
Lower Connoquenessing Sandstone.	
Sharon Coal.	
Sharon Conglomerate.	

LOWER CARBONIFEROUS, (950 TO 4,000 FEET.)

Mauch Chunk Shales (300 to 2,000 feet).

Greenbrier Limestone (150 to 800 feet).

Pocono Sandstone (500 to 1,200 feet).

DEVONIAN.

Catskill Sandstone (Hampshire, U. S. G. S.) 2,000 feet.

Chemung Shales (Jennings, U. S. G. S.), 2,500 feet.

Hamilton Shales (Romney, (U. S. G. S.), 1,200 feet.

Oriskany Sandstone (Monterey, U. S. G. S.), 250 feet.

UPPER SILURIAN.

Lower Helderberg Limestone / Salina Limestone and Shales } (Lewiston, U. S. G. S.). 1,200 ft.

Clinton Limestone { Rockwood U. S. G. S. / Cacapon, U. S. G. S. } 800 feet.

Medina { White Sandstone, Tuscarora, U. S. G. S. / Red Sandstone, Juniata, U. S. G. S. } 1,000 feet.

LOWER SILURIAN.

Martinsburg Shale (Hudson river), 2,000 feet.

Shenandoah Limestone (in part), 1,000 feet.

CAMBRIAN.

Shenandoah Limestone (in part), 1,000 feet.

Harper's Shale (1,200 feet).

SECTIONS ILLUSTRATING THE GEOLOGY OF THE PAN HANDLE AREA.

The order and character of the formations of the Pan Handle area are illustrated by the following type sections:

Chapline Hill, Wheeling, Section.

(Measured with hand-level).

	Ft.	in.	Ft.	in.	Ft.	in.
Top of hill, sand.						
Sandstone and shaly sandstone.......	60					
Gray limestone......................	3					
Buff sandy shales....................	27		136			
Gray limestone	10					
Shaly sandstone	27					
Buff shales..........................	8					
Limestone	1					
Washington coal....................	3					
Buff sandy shales....................	50					
Faint blossom coal, Waynesburg "A"...						
Gray limestone	3					
Buff shales..........................	12	10	101	6		
Gray limestone	1	6				
Shales and sandstone layers...........	25	10				
Limestone, Elm Grove...............	2					
Shales	4	4				
Waynesburg coal	2					
Shales	6					
Black slate	..					
Buff shales	4	4				
Shaly sandstone	3					
Buff shales	3					
Gray limestone, Waynesburg..........	2		103	2		
Thin sandstone and shales............	30	4				
Clay blossom, Uniontown Coal Horizon (?).........................,	0	8				
Sandstone	0	6			263	8
Buff shales	6					
Limestone, Uniontown	4					
Buff shales and sandstone............	41	4				
Green shale	4					
Limestone and shales, Benwood.......	86	8				
Sewickley Coal	0	6				
Limestone, Sewickley	33					
Redstone Coal	..	8	160	6		
Limestone, Redstone..................	18					
Shales (in part of area)..............	10	6				
Pittsburg coal { roof ..1—2; shales ..1; coal ....5 }	7	2				
Sandstone	35+					

Mr. Frank F. Grout measured with barometer the following section up a run north of the Baltimore & Ohio railroad, opposite the mouth of Carter run, east of Wheeling. The Pittsburg coal was concealed in the section, but its approximate position is indicated.

Section Opposite Carter Run, Ohio County.

	Ft.	in.	Ft.	in.
Sandy shales and limestone	207			
Coal, Washington	5			
Concealed	27			
Coal, Little Washington	2			
Concealed	27		317	6
Coal blossom, Waynesburg "A"	0	6		
Shales and limestone	45			
Limestone, slaty, Elm Grove	4			
Coal, Waynesburg	2			
Limestone and shales	36			
Black slate	0	3		
Limestone and shales, Uniontown	63			
Green shale, Fulton	2			
Limestone, Benwood	45			
Shales, limy	18			
Coal, slaty, Upper Sewickley	2			
Shales, limestone, streaks coal	18		244	3
Coal, Lower Sewickley	1			
Limestone brecciated, Sewickley	10			
Concealed	17			
Coal, Redstone	1			
Limestone, Redstone	8			
Concealed	16			
Pittsburg coal horizon	6(?)			
Concealed	12			

The following section near Twilight on Middle Wheeling creek was measured by hand level from the top of Fleahman gas well and combined with the well record:

Section at Twilight, Ohio County.

	Ft.	in.	Ft.	in.
Limestone, Middle Washington	8			
Concealed	45			
Coal, Washington	2			
Shales and concealed	51	6		
Sandstone, shaly	3			
Shales and concealed	17	8	118	10
Limestone	1	6		
Shales, buff	5	2		
Sandstone	2			
Shales, buff	31			
Limestone, Elm Grove	3			
Shales	2			

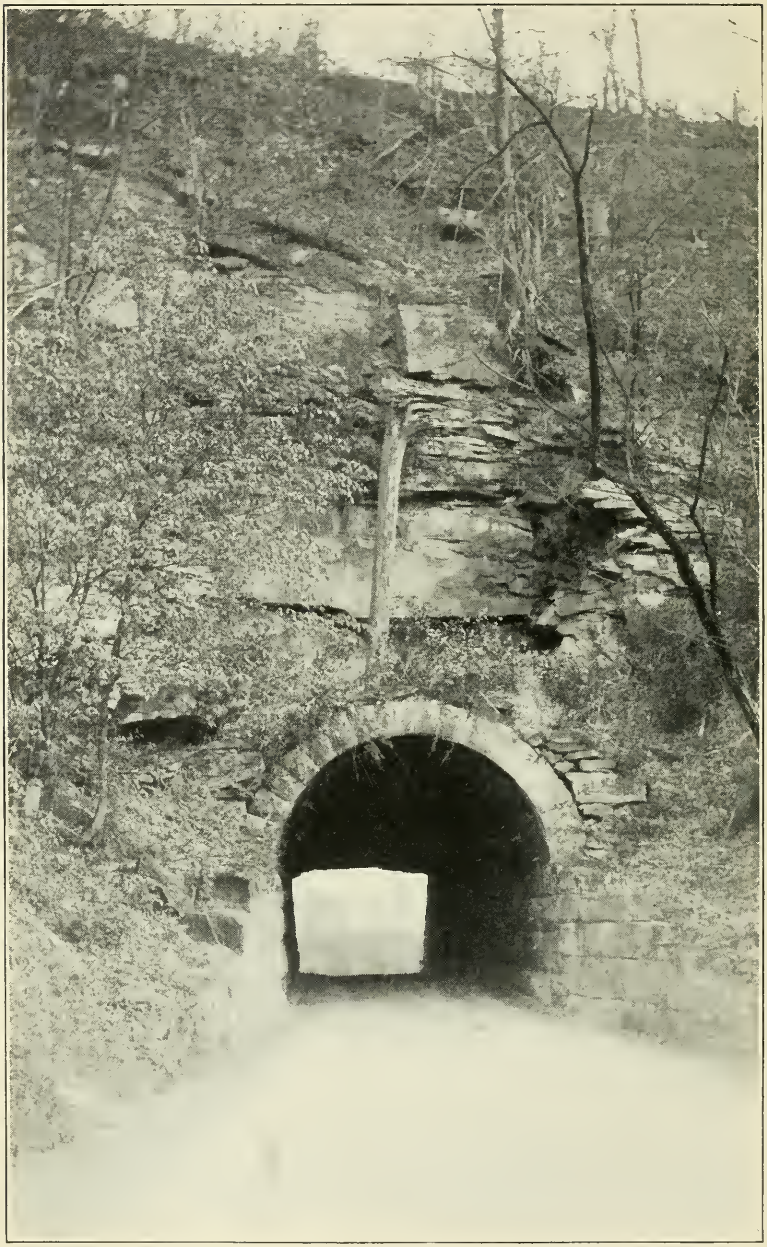

Plate III.—Wellsburg-Bethany Turnpike Tunnel, With Morgantown Sandstone Above, Brooke County.

	Ft.	In.	Ft.	In.
Coal, Waynesburg	3			
Shales	5	2		
Concealed	82	8		
Level Fleahman Well.				
Interval	90		270	10
Coal, Sewickley				
Interval	90			
Coal Pittsburg				
Interval to Dunkard Sand	484			

The longest section measured for the Dunkard Series is given under the discussion of that series, and was taken northeast of Valley Grove, giving a total thickness of 493 feet.

The sections given above, including the Monongahela Series, would indicate the average thickness of these rocks to be about 260 feet. The section below the Pittsburg coal to the upper Freeport coal, representing the Conemaugh Series, was made near Osburn's Mill on Kings creek in Hancock county.

Osburn's Mill Section, Hancock County.

	Ft.	in.	Ft.	in.	Ft.	in
Pittsburg Coal.						
Shales and concealed	60	2				
Shales and shaly sandstone	45					
Sandstone and concealed	75		225	0		
Concealed	30					
Shales	15					
Limestone fossiliferous, Ames	8					
Shales	7				465	6
Black slate	1					
Coal, Harlem	1	6				
Blue clay	3					
Shales and concealed	108		240	6		
Shales and sandstone	27					
Shales	25					
Shales, fine	40					
Sandstone	20					
Coal blossom, Upper Freeport	0					
Shales	5					
Limestone, Upper Freeport	4					
Shales	5					
Sandstone	6		37	0		
Shales	4					
Limestone	5					
Shales	8					
Coal, Lower Freeport	5	4				
Shales and sandstone to creek level	28					

The above section, while made with a barometer, was repeated three times, and may be taken as approximately correct, and it agrees closely with Orton's sections in eastern Ohio near the river.

The top of the section as measured is one mile south of the Upper Freeport horizon, so that the normal southern dip in this area of 20 feet was added to the interval above Ames. The 240 feet interval between Upper Freeport horizon and Ames was measured along the eastern dip of the Ames, three-fourths mile distant from the coal blossom, thus including a dip of possibly 30 feet. If this allowance is made, the section agrees closely with a vertical interval of 273 feet, measured further west on Kings creek by Dr. Edward Orton.

At New Cumberland Dr. I. C. White measured the following section of the Allegheny Series, as given in Volume II of West Virginia Geological Survey (p. 381):

New Cumberland Section, Hancock County.

Upper Freeport coal, not present.	Ft.	In.
Fire clay and limestone, Upper Freeport	5	..
Concealed and sandstone, massive	40	..
Flaggy sandstone and sandy shales	20	..
Coal, Roger or Lower Freeport	3	1
Shales and concealed	30	..
Sandstone, massive, Lower Freeport	70	..
Coal, Middle Kittanning	2	11
Fire clay and sandy shales	30	..
Coal, Lower Kittanning	3	..
Fire clay, Lower Kittanning	8	..
Sandy shales and concealed to low water in Ohio river	50	..
Interval, estimated to top of Pottsville	25	..
Total	287	3

These sections would give the total thickness of the coal measures in the Pan Handle area as 1620 feet, divided as follows:

	Feet.
Dunkard Series	600.
Monongahela Series	260.
Conemaugh Series	500.
Allegheny Series	260.
Total	1620

CHAPTER III.

THE DUNKARD SERIES.

The highest group of rocks in the Carboniferous of the Appalachian area, and the most recent formation in West Virginia, except the river alluvium, is the Dunkard series, so named in 1891 from Dunkard creek in southern Pennsylvania, by Dr. I. C. White, whose original description follows:

"The uppermost beds are found at the headwaters of Dunkard creek, a large stream which heads near the West Virginia-Pennsylvania line, on the eastern slope of the watershed separating the Ohio and Monongahela river drainage systems, and flowing eastward, puts into the Monongahela two miles above Greensboro, Greene county, Pennsylvania, and four miles north from the West Virginia line. This stream flows over the Permo-Carboniferous rocks from the source to the point at which it leaves the West Virginia line at Mount Morris, Pennsylvania, a distance of more than thirty miles, furnishing very fine exposures of these rocks along its banks and bluffs, hence the geographical name, Dunkard, which I have given the series." (U. S. G. S. Bull. 65, p. 20: 1891.)

On account of the supposed absence of coal seams of economic value in this series, it was named in the early days of the study of geology in this country the Upper Barren Measures.

From the presence of fossil plants of Permian age in the shales of this series, and the failure to find Permian animal remains, it was for a long time placed under a compromise term of Permo-Carboniferous. The discussion of the age of these rocks will be given at the close of this section.

The base of the Dunkard series has been placed by Dr. White at the horizon, where Permian plants have first been observed in the fossil flora, namely the Cassville shales just above the Waynesburg coal.

The following description of the Dunkard series is given by Dr. White in the coal report of the West Virginia Geological Survey (Vol. II, p. 101):

"As exhibited in West Virginia, the rocks of this series consist of a succession of brown and gray sandstones, interstratified with much red shale, many beds of limestone, and several thin, impure, and unimportant coal beds, the entire series being slightly gypsiferous throughout, though no accumulations of gypsum have taken place owing probably to the absence of any considerable thickness of limestone beds.

"In Ohio and northern Marshall counties, like Greene and Washington of Pennsylvania, this series holds less red shale and a greater proportion of limestone and gray limy shales than further to the southwest. The coal beds are also more numerous, and the sandstones less massive, the whole resulting in a gentle rolling topography, finely adapted to grazing and agriculture, except along the immediate gorges of the streams.

"As we pass southwestward, however, the coal beds all disappear except one (the Washington) before we reach the Little Kanawha river, and the limestones with one or two exceptions thin away into great masses of marly red shales, holding only nuggets of lime, while the sandstones thicken up, and, capping the ridges in long lines of cliffs, often make a rugged topography better fitted for grazing and fruit culture than for agriculture. When the massive sandstones disappear from the ridges or uplands, however, there frequently occur limited areas of beautiful rolling lands which yield abundant crops, the red marly shales being quite fertile from the disseminated limestone nuggets.

"The soils formed by the disintegration of the Dunkard beds have the reputation of producing a fine quality of wool in which the fiber is peculiarly firm and strong, so that its area is often known as the "sheep belt" of West Virginia, since probably 90 per cent of the sheep raised in the State are grown upon the outcrops of the Dunkard series. These rocks occupy a belt about 40 to 60 miles in width bordering the Ohio river and extending east from the same over portions or all of the following named counties: Ohio, Marshall, Wetzel, Tyler, Monongalia, and Marion (west of the Monongahela river), western Harrison and Lewis, Doddridge, Pleasants, Wood, Wirt, Ritchie, Calhoun, Gilmer, Roane, Jackson, and the uplands of Mason and southern Putnam, but tailing out into a narrow belt, which soon overshoots even the highest hills of Wayne, a short distance east from the Big Sandy river at the Kentucky boundary."

The succession of rocks in the type section on Dunkard creek from the head of the Pennsylvania fork in Gilmore township, Greene county, Pa., to Mount Morris is given below[1]:

Dunkard Creek Section.

	Ft.	In.	Ft.	In.
Concealed from top of Shough's Knob	165			
Sandstone; massive, Gilmore	40			
Shales, with limestone at base	15			
Sandstone and shales and concealed	100			
Shale, red	2			
Shales, gray	20			
Shale, marly	2		480	
Sandstone and shale	35			
Red shale	3			
Sandstone and shale	50			
Red shale	3			
Shales and sandstone, Nineveh	25			
Shales	20			
Coal, Nineveh	1	6		
Shales	28			
Limestone (No. X), Nineveh	7			
Shales, sandstone and concealed	100			
Sandstone, massive, Fish Creek	20			
Shales with fossil plants	10			
Coal, Dunkard { coal 0' 5"; slate 0 1; coal 0 6 }	1		223	1
Limestone	1			
Sandstone	10			
Shales	17			
Limestone, Jollytown	1	6		
Shales and sandstone	25			
Coal, Jollytown	1	1		
Calcareous shales, fossiliferous, fish teeth	0	6		
Limestone, Upper Washington	4			
Shales and sandstone	115			
Limestone, Middle Washington	3			
Shales	40			
Sandstone	35			
Shale	5		276	8
Coal, Washington, "A" { coal, impure 1' 2"; fire clay 2 6; coal 0 6 }	4	2		
Shales and sandstones	60			
Limestone, Lower Washington	5			
Shales	5			
Coal, Washington, slaty	5			
Shales and sandstones, including coal bed near center	110			
Coal, Waynesburg "A"	2	6	177	6
Shales	10			
Sandstone, Waynesburg	50			
Shales, with fossil plants (Cassville)	5			
Waynesburg coal.				
Total			1162	3

1. I. C. White in W. Va. Geol. Sur. Vol. II, p. 102.

Two sections are added also, which were measured by Dr. I. C. White in Washington county, Pennsylvania, the adjoining county to the area described in this report. These two sections show the succession of rocks in the lower portion of the Dunkard Series, with intervals less than in the Dunkard creek section. These intervals are further decreased in the Ohio county, West Virginia sections.[1]

Washington, Pennsylvania Section.[1]

	Ft.	In.	Ft.	In.
Limestone, Jollytown			10	
Shale			5	
Coal, Jollytown			1	
Sandstone	10			
Dark shale	8			
Limestone, Upper Washington	30			
Concealed	50		190	
Coal, blossom	0			
Concealed	80			
Limestone, Lower Washington	12			
Coal, Washington	7			
Clay	4			
Sandstone	9			
Concealed	10			
Limestone	2			
Shales, limestone, concealed	65		117	6
Black slate	1	6		
Limestone	4			
Blue shale	15			
Waynesburg coal.				
			323	6

Near Taylorstown, Washington County, Pennsylvania.

	Ft.	In.	Ft.	In.
Limestone, in fragments			0	
Shales and sandstone			40	
Coal, blossom, Jollytown	0			
Shale	10			
Limestone	6			
Concealed	20			
Limestone	12			
Sandstone	15			
Coal	0	8	203	8
Concealed	40			
Limestone	15			
Concealed	45			
Limestone	10			
Concealed	5			
Coal	0			
Concealed, with much limestone	25			

1. U. S. G. S. Bull. 65. p. 29, 30.

	Ft.	In.	Ft.	In.
Coal, Washington	6			
Concealed, with a limestone	35			
Coal blossom, Waynesburg "B"	0	2		
Concealed	40		141	2
Coal blossom, Waynesburg "A"	0			
Waynesburg sandstone	50			
Shales	10			
Coal, Waynesburg.				
			384	10

The Dunkard series of rocks covers most of the area of Ohio and Marshall counties, being cut out in the stream valleys where the lower formations are exposed. It is also found on the dividing ridges in the southern part of Brooke county. The series consists of sandstones, sandy shales, limestones, and thin coal seams. The red shale characteristic of the formation further south, is found in this area in irregular disconnected deposits. The maximum thickness of the series in West Virginia is 1100 to 1200 feet, and the greatest thickness measured in Ohio county is 600 feet.

The following sections in Ohio county will illustrate the character of the rocks and the intervals in the Dunkard Series in this area:

County Farm, West of Elm Grove.

	Ft.	In.	Ft.	In.
Sandstone shaly at top of ridge				
Shales and thin shaly sandstone layers	30			
Sandstone	2			
Shales, buff	8			
Limestone, Middle Washington	8	10	92	2
Shales	30			
Black slate	0	4		
Limestone, Lower Washington	2			
Shales	9			
Coal Washington	2	6		
Shales, dark	15			
Limestone, nodular	3			
Shales	16			
Limestone	2+			
Shales, sandy	25			
Coal blossom, Waynesburg "A"	0		103	4
Shales, buff	16			
Sandstone	0	10		
Shales, blue	8			
Limestone shaly, blue, Elm Grove	10			
Shales	5			
Waynesburg coal.				
			193	6

Hill Above Elm Grove Shaft Mine.

	Ft.	In.	Ft.	In.
Shales and concealed from top of hill......	72	4		
Sandstone	4		97	
Concealed	20	8		
Coal blossom, Dunkard....................	0	6		
Sandy shales and concealed...............	70	4		
Limestone, blue, Middle Washington.......	15			
Concealed	10	4	116	2
Black thin slate..........................	1			
Shales, sandy	7	8		
Limestone nodular, Lower Washington......	1			
Shales buff, sandy........................	10	4		
Coal blossom, Washington.................	3			
Concealed	7	2		
Shales, buff	15			
Coal blossom, Little Washington..........	2			
Shales and concealed......................	20	8	127	4
Coal blossom, Waynesburg "B".............	1			
Concealed	15	6		
Limestone	1			
Concealed	26			
Sandstone shaly, Waynesburg..............	18			
Concealed	8			
Limestone boulders, Elm Grove............	10			
Waynesburg coal.				
			340	6

The section made on the county farm shows a faint blossom of coal about 35 feet above the Waynesburg coal, which probably represents the horizon of the Waynesburg "A" coal. In the typical Dunkard creek section this coal is found 65 feet above the Waynesburg, while the interval from the Waynesburg to the Washington coal is 182 feet, which is reduced in the county farm section to 103 feet and 4 inches, and to 101 feet and 6 inches in the Chapline hill section at Wheeling. This county farm section only reaches 98 feet above the Washington coal and apparently does not reach any higher coals.

A comparison of the Dunkard creek section, the Washington county sections given above, and the sections in Ohio county, West Virginia, shows the intervals decreasing to the westward.

In the section above the Elm Grove coal shaft, the blossoms of two coals are found 78 and 99 feet above the Waynesburg coal, which may represent the Waynesburg "B" and the Little Washington coals. The interval between the Waynesburg and Washington coals has increased to 127 feet, and one mile east at Peter's creek, it is 130 feet.

In the Elm Grove section, the coal 131 feet and 2 inches above the Washington coal would be the Jollytown or the Dunkard. When this section is studied in comparison with those near the eastern side of the county beyond Valley Grove, this coal would correspond better with the Dunkard horizon. In the Dunkard creek section the interval between the Dunkard and Washington coals is 330 feet, but in the eastern part of Ohio county it is reduced to 116 feet and the Jollytown coal has apparently disappeared.

The portion of the Dunkard Series above the Dunkard coal horizon in the Wheeling and Elm Grove area as well as farther east, contains sandy shales and sandstones, in places over one hundred feet in thickness. It is not always possible to determine the upper and lower limits of the massive sandstones, as they grade into shaly sandstone and then into sandy shales. Some of the sandy shale outcrops when followed into steep walled ravines are found to represent solid sandstone. When they cannot be followed in this way, there remains an element of doubt as to whether the formations are solid sandstones or shales.

Four miles northeast of the Elm Grove shaft two sections were measured on Dixon and Battle runs. In this area the interval between the Waynesburg and Washington coals varies within short distance, but the average interval is 112 feet in vertical sections.

Section on Dixon Run.

	Ft.	In.	Ft.	In.
Limestone	1			
Concealed	27			
Sandstone, shaly	2		96	
Concealed	36			
Shales with thin limestone	30			
Coal blossom, Washington	2			
Shales, buff	5			
Limestone	8			
Concealed	36			
Limestone nodular	0	10		
Shales, blue	8			
Coal blossom, Waynesburg "A"	0	10	107	2
Black slate	1			
Concealed	14			
Limestone	2			
Shales, sandy	25			
Limestone, blue shaly, Elm Grove	1	6		
Shales	3			
Waynesburg coal.				
			203	2

On the hill to the northeast of Dixon run a ten-inch coal blossom is found 294 feet above the Washington coal. The interval to the Nineveh coal in this area is 240 to 260 feet. With due allowance for the rise of the strata, northward, this blossom probably represents the Nineveh coal.

The following section on Battle run, one mile east of the last locality, shows a heavier interval between the Waynesburg and Washington coals, but the distance between the two outcrops is one mile along the north rise of the strata, which would probably reduce the vertical interval to about 120 feet. With this correction the section would correspond with the one above the Elm Grove shaft. If the same correction for dip be made in the interval between the Washington and Dunkard coals, this distance of 115 feet would correspond with the intervals further east.

Section on Battle Run.

	Ft.	In.	Ft.	In.
Shales, sandy	3			
Coal blossom, Dunkard	0	10		
Limestone	1+			
Concealed	40			
Shales, buff	18			
Sandstone, shaly	4		135	10
Concealed	22			
Shales, sandy	9			
Shales, buff	18			
Limestone	5			
Concealed	18			
Coal blosson, Washington	1			
Black slate	.5			
Sandstone	4			
Shales, plate-like	5			
Shales and limestone layers	36			
Concealed	15		138	
Black slate, Waynesburg "A"	1			
Concealed	40			
Limestone	1			
Shales, fine	25			
Limestone, Elm Grove	5			
Waynesburg coal.				
			273	10

In the hills on the south side of Wheeling creek, across from Battle run, the Waynesburg-Washington coal interval is 120 feet and 10 inches. On Point run, east of Roney's Point, the interval

is 104 feet, while two and one-half miles south near Twilight, the interval is 118 feet and 10 inches, as measured with hand level.

On the south side of Little Wheeling creek, the Little Washington coal, fourteen inches thick with a sandstone roof, has been mined on a small scale. It is found 27 feet and 10 inches below the Washington seam.

Three-fourths mile east of Battle run on McGraw's run, the Washington coal was opened many years ago for cânnel coal and used in the manufacture of coal oil. On this run the Waynesburg "A" coal is found 84 feet below the Washington coal, and the Little Washington coal, eight inches in thickness, is 30 feet below the Washington.

On McGraw's run about 30 feet above the Washington coal is a one-foot vein of coal with three feet of black slate above, which may represent the Washington "A" coal. A four inch coal blossom with limestone below it, is found 20 feet higher.

Two miles east of McGraw's run the following section was measured in the Baltimore & Ohio railroad cuts and the ravines north and south; and is one of the most complete sections made of the Dunkard series in the area, extending from the Washington coal to above the Windy Gap coal, a thickness of 495 feet, to which should be added 110 feet, the estimated interval from the Washington to the Waynesburg coal, giving a total thickness of the Dunkard at this point of 605 feet.

Section One Mile and a Half Northeast of Valley Grove.

	Ft.	In.	Ft.	In.
Buff shales and concealed	100		100	
Coal blosson, Windy Gap	0	3		
Sandstone	0	10		
Shales, coarse	18		144	1
Sandstone	5+			
Shales and concealed	75			
Buff shales and sandstone layers	45			
Black slate, Nineveh coal horizon	0	2		
Shales and concealed	70			
Shales	10		123	2
Sandstone, Fish Creek	30			
Buff shales	10			
Clay shale filled with fossil plants	3			

Coal Dunkard		1	6		
Black shales		2			
Limestone		4			
Shales		4			
Shaly sandstone		12			
Shales		10			
Limestone, brecciated Middle Washington		10			
Shales		9			
Shaly sandstone		1	6	118	4
Shales and limestone layers		18			
Limestone		10			
Shales, blue		7	8		
Black slate		0	4		
Limestone (quarried) Lower Washington		20			
Clay shale		5			
Black slate		0	10		
Sandy shales		2	6		
Washington Coal.	Black thin slate	1			
	Coal	1			
	Sandy plate shales	2	6	7	8
	Sandstone	0	2		
	Thin black slate	2			
	Coal	1			
Blue and red sandy clay				2	
				495	3

The coal, 118 feet and 4 inches above the Washington, is exposed in most of the ravines in the eastern part of Ohio county near the National road, and it has been mined on a small scale in two or three places. This coal has a slate or clay parting about 10 inches from the bottom and the overlying shale is filled with fossil leaves. These characters correspond with the Dunkard coal in Pennsylvania, rather than with the Jollytown, and the heavy sandstone above the coal would leave but little doubt in this identification. The Jollytown coal is apparently absent in Ohio county, though some of the black slates above the Washington coal in other sections may represent this horizon.

The section given above is one of the few sections which shows the Nineveh coal horizon, and the only one with the higher coal, 144 feet above the Nineveh, which in all probability represents the Windy Gap horizon. This coal is found at a number of places along the high ridge road to the south of the National road, and is covered by fine buff shales. The uppermost beds are concealed in the grass covered knob which rises to 1440 feet, forming the highest point in Ohio county.

A long section was measured in the southeastern part of Ohio county on the hill south of Ladley run and below its mouth. The coals above the Washington are apparently concealed, while

the black slates do not come at the correct intervals for the Dunkard or Nineveh coal.

Section South of Ladley Run.

	Ft.	In.
Shales and shaly sandstone	72	
Limestone	3	
Shales, (partly red)	35	8
Limestone, blue	1	
Concealed	18	
Shales	7	9
Black slate	0	6
Shales, sandstone, and concealed	121	6
Black slate, faint blossom	0	3
Shales	5	
Black slate	0	6
Concealed	23	
Shaly sandstone	18	
Concealed	10	4
Coal blossom, Washington	2	
Shales and concealed	15	6
Coal blossom, Little Washington	0	3
Shales	5	2
Limestone	1	8
Concealed	10	
Shaly sandstone	12	
	363	1

A section was measured south of Dallas on Turkey run, which, taken in connection with the Armstrong gas well, extends from the Waynesburg coal to above the Nineveh.

If the interval between the Waynesburg and Washington coals be taken as 110 feet, then the black slate near the bottom of the section would be 116 feet above the Washington, which would be the horizon of the Dunkard coal. The Nineveh coal probably comes in the 70 feet of concealed rocks, 120 feet above the Dunkard horizon. The Pittsburg coal in this well was found 316 feet below the Waynesburg.

Section on Turkey Run South of Dallas.

	Ft.	In.
Sandstone	75	
Fine shales	40	
Sandstone	5	
Shales	10	
Shaly sandstone	18	
Shales and concealed	70	
Limestone, blue	1	6
Shaly sandstone	14	
Shales and shaly sandstone	12	
Black slate	0	4
Shales	9	
Limestone	4	
Concealed	18	

Black slate, Dunkard coal horizon	0	4
Sandstone	6	
Shales, fine	20	
Interval in Armstrong well to Waynesburg coal	200	
	503	2

Just north of the town of Dallas the following section was measured. The top of this section corresponds to the top of the last one, both starting at the cross road near the center of the town. The Dunkard coal was not reached in this section. The massive sandstone near the base of this section would be about the horizon of the Fish creek.

Section North of Dallas.

	Ft.	In.
Sandstone	60	
Shales	45	
Sandstone	15	
Shales	30	
Sandstone	3	
Shales	40	
Limestone	3	
Shales	9	
Coal blossom, Nineveh	0	3
Shales	10	
Limestone	4	
Shales	32	
Sandstone	2	
Shales	18	
Sandstone, Fish Creek	45	
Limestone	2	
Shales and sandstone	10	

Southwest of Dallas and south of Twilight on Winters run in Marshall county, a section of the Dunkard is exposed from the Washington coal to the Dunkard coal horizon.

Winter's Run Section.

	Ft.	In.	Ft.	In.
Sandstone and concealed, Fish Creek	54		56	
Black slate, Dunkard coal horizon	2			
Shales	8		120	3
Limestone	6			
Concealed	10			
Limestone and shales	16			
Limestone	14			
Shales	5			
Black slate	0	3		
Concealed	15			
Limestone, Middle Washington	15			
Concealed	30			
Limestone, blue, Lower Washington	1			
Coal, slaty, Washington	5		5	
			181	3

In the northern part of Ohio county, the Dunkard Series, on account of the northward rise of the strata, is much thinner, but the intervals remain about the same as further south.

Section One Mile and a Half South of West Liberty.

	Ft.	In.	Ft.	In.
Coal blossom, Dunkard	0	3		
Concealed and shales	81			
Coal blossom, Washington "A"	0	6	126	9
Concealed	36			
Sandstone	3			
Shales	6			
Black slate and blossom, Washington coal horizon	2			
Limestone, blue	1			
Concealed	62			
Sandstone, gray	3		119	
Concealed	45			
Limestone, blue, shaly	4			
Shales	2			
Waynesburg coal.				
			245	9

Section on Murray Run.

	Ft.	In.	Ft.	In.
Sandstone and shales	63		63	
Coal, blossom thin, Dunkard	—			
Concealed	27			
Shales, sandy	15			
Limestone boulders	—		106	6
Concealed	22			
Shales, sandy	20			
Coal blossom, Washington "A"	0	6		
Concealed	22			
Coal blossom and slate coal horizon Washington	1+			
Limestone, blue	2			
Concealed	9			
Limestone	2		111	2
Concealed and shales	60			
Limestone, blue	0	10		
Black slate	0	4		
Concealed	36			
Waynesburg coal.				
			280	8

Section Northwest of Potomac.

One mile and a half northwest of Potomac and just east of Long's run, the following section was measured with hand level.

	Ft.	In.	Ft.	In.
Sandy shales	18			
Sandstone and concealed, Fish Creek	45		64	10
Limestone, gray	1			
Black slate, Dunkard coal horizon	0	10		
Sandstone, shales and concealed	117		117	
Coal blossom, Washington	5			
Concealed	15	2		
Black slate, thin blossom, Little Washington	0	6		
Shales and concealed	20	8	82	4
Shales and sandstone layers	36			
Limestone blue, shaly, Elm Grove	3			
Shales	2			
Waynesburg coal.				
			264	2

This section apears to be normal above the Washington coal, but shows a decreased interval between the Waynesburg and Washington coals. The lower coal with the shaly blue Elm Grove limestone above is without doubt the Waynesburg, and the heavy blossom 82 feet higher would not correspond with any coal near this horizon except the Washington. The interval was measured twice with the barometer and finally with the hand level so that there must be a local decrease in this interval, as further south and west this interval measures about 110 feet.

The different beds of the Dunkard Series have been named as follows and have a total exposed thickness in the Pan Handle area of 600 feet.

DESCRIPTION OF THE DUNKARD FORMATIONS.

Windy Gap Limestone.
Windy Gap Coal.
Gilmore Sandstone.
Nineveh Sandstone.
Nineveh Coal.
Nineveh Limestone.
Fish Creek Sandstone.
Dunkard Coal.
Jollytown Coal.
Washington Limestones.

Washington "A" Coal.
Marietta Sandstones.
Washington Coal.
Washington Sandstone.
Little Washington Coal.
Waynesburg "B" Coal.
Waynesburg "A" Coal.
Waynesburg Sandstone.
Elm Grove Limestone.
Cassville Plant Shale.

The Windy Gap Coal.

The highest known coal of the Dunkard Series was named the Windy Gap from a locality in Greene county, Pennsylvania, where the blossom and slate reach two feet in thickness. It is also found high in the hills at Bellton, Marshall county, West Virginia, about 1050 feet above the Waynesburg coal.

The blossom of this coal, three inches thick, is found in the high ridge in the eastern part of Ohio county, just south of the National road. It is there covered by a mass of fine buff shales, and the horizon is about 500 feet above the Waynesburg coal. This measurement would make the thickness of the Dunkard series in Ohio county about one-half that in Pennsylvania and in Marshall county, West Virginia. The series extends 100 feet above the Windy Gap coal horizon, giving the total thickness of 600 feet for the Dunkard in Ohio county. The interval between the Windy Gap and Nineveh coals, 144 feet, consists of shales and sandstones, which in part probably represent the Nineveh sandstone of Pennsylvania.

The Nineveh Coal.

The Nineveh coal was named by Dr. John A. Stevenson from the village of Nineveh, Greene county, Pa. In Ohio county this coal appears to be represented by a black slate, 120 feet above the Dunkard coal. In the typical Dunkard creek section this interval is 165 feet.

The Nineveh coal, which has no economic importance in Ohio county, becomes rather pure and has been used for smithing purposes further east in Monongalia, Marion, Wetzel, and Marshall counties, ranging in thickness from six inches to two feet.

The Nineveh Limestone.

Below the Nineveh coal, 25 to 30 feet, according to Dr. I. C. White, "there is found a limestone that appears to have a very wide distribution. It usually occurs in several layers, and these may be separated by marly or sometimes bituminous shale, the whole often 20 or more feet in thickness. Some of the layers of limestone are of fair quality, while others are quite impure."

In the southern portion of Ohio county where the Nineveh coal horizon is exposed, the interval below the coal contained some shales, but was for the most part concealed. On the Dallas hill a four foot limestone was found ten feet below the coal, and probably represents a part of the Nineveh limestone.

The Fish Creek Sandstone.

"A very massive sandstone, 135 to 150 feet below the Nineveh coal, forms great cliffs along the waters of Fish creek in Springhill township, Greene county, Pa., and was named from this stream by Stevenson."[1]

Through the higher portions of the Dunkard series in Ohio county heavy sandstones and coarse, sandy shales are found above the Dunkard coal horizon and below the Nineveh, thus corresponding in position to the Fish creek sandstone.

This sandstone east of Valley Grove is 80 feet below the Nineveh coal and 10 to 15 feet above the Dunkard. In the ravines north of the National road, the sandstone and shaly sandstone come just above the Dunkard coal and were traced 117 feet upward. The lowest portion was a coarse sand and cross bedded, while the upper portion was quite shaly.

Up Point run the sandstone begins 117 feet above the Washington coal and continues 72 feet to the top of the hill. Below West Liberty, the sandstone formation begins 60 to 70 feet above the Dunkard. On Marlow run, the sandstone begins 135 feet above the Washington coal. It is found in about the same position out Woods run, Boggs run, and in nearly all sections which reach this level in the series. The disintegration of this sandstone forms the sandy soils over a large area in the central and eastern portions of the county north of the National road. It also forms the sandy slopes of many of the valleys, and the large

1. U. S. G. S. Bull. 65, p. 33.

sandstone boulders, some of which are ten and twelve foot cubical blocks, found in the southeastern part of the county, toward Dallas, represent the Fish creek sandstone.

North of Glenn's run, the sandstone has been eroded until the sloping hillsides covered with grass show few exposures of it, but in a field near the head of the run a lone pedestal of coarse sandstone 12 feet high and 5 or 6 feet in diameter, stands as a monument to the past extension of this great sandstone. The base of the pyramid is 216 feet above the Waynesburg coal.

The Dunkard Coal.

The Dunkard coal was named from Dunkard creek, Pennsylvania, by Dr. Stevenson. According to Dr. White, this coal "is seldom more than 12 to 15 inches thick, but is almost always double bedded, having a thin layer of slate near its center. It covers a considerable area in western Marion, Monongalia, Wetzel, and Marshall counties and has occasionally been mined by stripping along the streams." Its position is usually 140 to 160 feet below the Nineveh coal, 50 to 60 feet above the Jollytown, and 260 to 300 feet above the Washington coal.

Through the eastern part of Ohio county there is a thin coal blossom or black slate quite persistent at a horizon 105 to 120 feet above the Washington coal. With the decreased intervals in Ohio county, this horizon might correspond to the Dunkard or the Jollytown coal. In most cases there seems to be but little doubt that this is the Dunkard coal horizon. The coal is fifteen to eighteen inches thick with a slate parting about ten inches from the bottom. The roof shales are filled with fossil plants, and above the coal is the heavy sandstone formation identified as the Fish creek. All of these characters agree with the Dunkard of Pennsylvania and not with the Jollytown coal.

The Dunkard coal is exposed in the Baltimore & Ohio railroad cuts, one mile west of the Pennsylvania state line. It is 18 inches thick covered with two feet of thin black shales containing fossil leaves. The coal is separated from a blue limestone below by one or two feet of shales.

North of the last locality and up the ravine to the west of the county road, on the Atkinson farm, this coal was formerly mined for local use. The vein at this place appears to be double bedded, the lower bench, about fourteen inches thick, is separated

from the upper four inch layer by five or six feet of clay shale, which weathers into a typical clay. This clay, especially near the upper thin coal seam, is a mass of fossil plant stems and leaves. The horizon is 118 feet and 4 inches above the Washington coal.

One mile east on the Korn farm near the long farm road to the Chambers place, this horizon, 117 feet above the Washington coal, is marked by two feet of coal black shale resting on two feet of limestone. Careful examination of this shale failed to show any trace of fossil leaves.

South of Valley Grove this coal is about ten inches in thickness and 108 feet above the Washington coal. It has been mined at this place by stripping, but the small thickness made the work unprofitable, even for local use. The blossom of the Dunkard coal is found in most of the ravines and hills of the southern part of Ohio county, south of West Liberty, on Murray run, near Roney's Point up Point run, near Dallas, and many other places as indicated on the Ohio county economic map. The interval between the Dunkard and Washington coals will average about 110 feet. While the coal is not of economic importance in itself, it is a valuable guide to the lower coals whose distance below the surface can then be closely approximated. The Waynesburg coal should be found about 220 feet lower, and the Pittsburg, 460 to 480 feet below the Dunkard.

The Jollytown Coal.

The Jollytown coal was named by Dr. Stevenson, from its outcrop near a village of that name in Greene county, Pa. This coal, with a thickness of two feet, has been mined in Monongalia county, West Virginia, and Greene county, Pa. Dr. I. C. White states[1] that "along Dunkard creek the Jollytown coal is nearly always present and seldom less than one or two feet thick. It becomes a very important key rock over a wide region, since there are seldom any other coals below it for an interval of 250 feet. It extends almost without a break across Greene, Monongalia, Marion, and Harrison counties, but appears to thin away in Doddridge.

"Throughout Monongalia, Greene and Marshall counties, the interval between this bed and the Washington coal below is about

1. U. S. G. S. Bull. 65, p. 34.

Plate IV.—Lower Washington Limestone Near Valley Grove, Ohio County.

275 feet, but westward in Washington county, Ohio, the interval thins away to 200 feet, and practically the same measurement is found in Washington county, Pa."

The description quoted above shows that the Jollytown coal is quite persistent through Pennsylvania and West Virginia, but the present work in Ohio county seems to indicate that this coal has disappeared or has become so thin and possibly changed to a black slate making its identification very uncertain.

The Washington Limestones.

The three Washington limestones were named by Dr. Stevenson from Washington, Pennsylvania, and designated as the Upper, Middle, and Lower.

The *Upper Washington Limestone* is found in the typical sections just under the Jollytown coal. It is thus described in Pennsylvania by Dr. Stevenson,[1] "The Upper Washington limestone is a fine stratum of such marked characteristics that it cannot be mistaken for any other in the series. In all portions it weathers to an almost snowy whiteness with the slightest tinge of blue. The upper part is quite slaty and is blue on the freshly exposed surface. The middle layers are dark, almost black, and frequently mottled with drab. They are exceedingly brittle, ring sharply when struck, and yield a limestone of superior quality . . . . The top and bottom divisions are persistent, but the middle or dark portion disappears soon after entering Greene county."

In Washington county, Pennsylvania, this limestone reaches a maximum thickness of 30 feet, made up of layers of limestone and shales, while in Greene county it decreases to four and eight feet. In Ohio county, West Virginia, this limestone varies from 4 to 8 feet. On the John Hand farm, one mile west of Twilight, this limestone is eight feet thick, very hard, and has the following composition:

Lime carbonate	92.42	per cent.
Magnesium carbonate	0.91	" "
Iron and alumina oxides	1.60	" "
Silica	5.00	" "
	99.93	" "

1. Second Geol. Survey of Pa., vol. K., p. 45; 1875.

The *Middle Washington Limestone* was originally described by Dr. Stevenson as follows:[1] "As found in Washington county, it is a massive buff limestone from six to fifteen feet thick, which, when freshly broken, is of dull flesh color and glistens with innumerable bits of calcspar. So great is the quantity of iron present that the rock after long exposure weathers rusty yellow to a depth of several inches and finally, after exfoliation, crumbles. Toward the base there are some thin earthy layers which have a slaty fracture, and containing less of iron, do not yield so readily to the weather as does the upper portion. The upper or ferruginous part of the bed is richly fossiliferous, but as the fossils are not silicified, it is rarely possible to obtain specimens in identifiable condition."

The Middle Washington limestone is found in nearly all the Dunkard sections of Ohio county, and it is quarried in several places for road material. It is a blue rock quite compact and hard, weathering to a white or gray color. It varies in thickness from 10 to 20 feet and is found 30 to 45 feet above the Washington coal.

A quarry was formerly worked in this limestone on the county farm west of Elm Grove. The limestone here is nearly 9 feet thick and is 40 feet above the Washington coal. The limestone in this quarry shows the following structure:

	Ft.	In.	Ft.	In.
Shales, buff	8			
Limestone, gray, mottled	1	2		
Limestone, blue, shaly	0	8		
Black clay shale	0	2		
Limestone, blue, shaly	0	5		
Limestone, blue, irregular fracture	2		8	10
Limestone, shaly	0	3		
Limestone, blue, hard	1	8		
Shales, blue	1			
Limestone, gray, hard	1	6		
Shales, buff	6			

An average sample of this limestone was taken with the shale layers removed and analyzed in the Survey laboratory with the following results:

Lime carbonate	72.38	per cent.
Magnesium carbonate	1.36	" "
Iron and alumina oxides	2.60	" "
Silica	20.90	" "
Water and organic matter	2.65	" "
	99.89	" "

1. Loc. cit., p. 49.

The analysis shows the rock to be a siliceous limestone low in magnesia, iron and alumina. The Middle Washington limestone above the Elm Grove shaft is 30 feet above the Washington coal and 15 feet in thickness. The same rock with nearly the same thickness is found on the John Hand farm, west of Twilight. Near Valley Grove this limestone is ten feet thick and brecciated. On Winter's run in the northern part of Marshall county, it is 15 feet thick and 30 feet above the Washington coal.

The *Lower Washington Limestone* in Pennsylvania was described by Dr. Stevenson as follows:[1] "It everywhere accompanies the Washington coal. In Greene county it is commonly found at from six to eight feet above the coal, though at one locality on Dunkard creek the interval is twenty feet. It is dark blue, with some flesh colored layers, weathers bluish white and has a slaty fracture. Its thickness varies from six inches on Hunter's fork to three or five feet at most of the other localities in the county. In general appearance it is quite as well marked as is the Upper Washington, so that one is frequently enabled to determine the horizon of the Washington coal when everything is concealed except fragments of this limestone."

According to Dr. I. C. White this limestone in Washington county reaches a thickness of 20 to 30 feet, interstratified with shales, while outside of this county it is seldom more than 5 to 10 feet thick.

The Lower Washington limestone up Ladley run in Ohio county is two feet thick and is found over the Washington coal. It is seen over the Washington coal with the same thickness in the county farm section near Elm Grove, and also in the hill above the Elm Grove shaft.

Beyond Valley Grove, on the Korn farm, a limestone has been quarried eight feet above the Washington coal, corresponding in position to the Lower Washington limestone, but it here reaches a thickness of 20 feet with its parting shale layers. The upper ledge forms a waterfall of six feet in height and is composed of limestone with shaly limestone layers. (See plate IV.)

The harder layers have been used for road material, but the shaly limestone soon crumbles under the action of the weather.

1. Loc. cit., p. 50.

The composition of the more resistant layers is shown by the following analysis made in the Survey laboratory:

Lime carbonate	60.89	per cent.
Magnesium carbonate	2.28	" "
Iron and alumina oxides	12.00	" "
Silica	18.70	" "
Water and organic matter	5.81	" "
	99.68	" "

This analysis and that of the Middle Washington limestone show these rocks to be quite impure, being high in silica, and the Lower Washington is high in iron and alumina. The combination of low lime carbonate and high silica would make these rocks resistant to weathering action and better adapted to road material than for manufacture of lime.

The Lower Washington limestone on the Korn farm is quite fossiliferous in some of its layers, especially in the upper portion. The fossils are minute brachiopods and gasteropods. This limestone, 20 feet thick, is found a quarter of a mile up the road, one-half mile northeast of Valley Grove. The upper eight feet is quarried for road material, and the lower twelve feet forms a water fall. The base of the limestone is about eight feet above the Washington coal.

The Washington "A" Coal.

In Pennsylvania and Monongalia county, West Virginia, a bed of slaty coal is found 70 to 80 feet above the Washington coal, and was designated as the Washington "A" coal.

The blossom of this coal, 3 to 6 inches thick, is seen in a number of the Ohio county sections. Near Valley Grove it is 27 feet above the Washington coal. Near West Liberty the interval is 45 feet, and on Murray run, 22 feet.

The Marietta Sandstones.

As the Dunkard series is followed southward in West Virginia, the interval between the Washington and Jollytown coals includes a large sandstone deposit, 100 feet or more in thickness, separated into ledges by shales. This sandstone horizon has been named by Dr. I. C. White the Marietta sandstones from their occurrence at Marietta, Ohio, where they have been quarried for building stone and grindstones.

In the Ohio county area this interval contains limestones and thin coal seams, but the sandstones and sandy shales comprise a large portion of the rocks in this interval, and probably represent a transition between the typical Pennsylvania section and the sandstone section further south in West Virginia.

The Washington Coal.

The Washington coal is the most important seam in the Dunkard series, and with its included shales or slates reaches a thickness of eight feet and six inches in Ohio county. This coal is always multiple bedded, the individual seams being thin and slaty, the best coal is found near the bottom.

Dr. I. C. White gives a section of this coal from near Farmington, in Marion county, West Virginia, which well illustrates its character, and states that the only good coal is the two and a half feet at the bottom. The upper six feet is too closely mingled with the shales to be of any economic importance:[1]

	Ft.	In.	Ft.	In.
Coal	0	6		
Shale	0	3		
Coal and shale	0	8		
Coal	1	0		
Shale	0	4		
Coal	0	5	6	1
Shale	0	3		
Coal	1	0		
Shale	0	4		
Coal	1	1		
Shale	0	3		
Coal, fair	2	0		
Slate	0	2	4	8
Coal, good	2	6		
			10	9

A section of the Washington coal on the Taggart farm on McGraw's run in Ohio county shows:

	Ft.	In.
Coal, slaty	1	6
Shale	4	
Coal and slate	3	0
	8	6

1. U. S. G. S. Bull. 65, p. 37.

Further east on the Korn farm, the coal shows:

	Ft.	In.
Black thin slate	1	
Coal	1	
Sandy shales	2	6
Sandstone	0	2
Black thin slate	2	
Coal	1	
	7	8

The coal and slate form a heavy blossom throughout Ohio county, so that the Washington coal is readily followed along an outcrop 100 to 127 feet above the Waynesburg coal. The Washington coal is nowhere in this region of any commercial importance and it is worked in but few places even for a farmers' supply.

The most extensive opening into the Washington coal is on the Taggart farm, where entries were driven in the early 60's to secure a supply of so-called cannel coal for the manufacture of coal-oil. The main entry, six feet high, and driven a distance of a quarter mile, still stands as firm as in the days of the old oil factory. The slaty coal yielded more refuse ash than oil, so that the unprofitable enterprise was soon abandoned. The site of the old factory is now marked by hills of red slate or ash. The old name still clings to this coal and it is locally known as the cannel seam.

This coal rests on a clay or shale floor, and it is covered by two to eight feet of shales. Above Valley Grove and up Point run these roof shales are filled with plant remains. Up McGraws run the shales below the coal carry the fossil leaves.

The Washington Sandstone.

Dr. I. C. White states that "very frequently the Washington coal rests directly upon a flaggy sandstone, often finely laminated, brown, micaceous, and containing vegetable fragments in great quantity.

This stratum, which was called the Washington sandstone by Professor Stevenson, occurs over a wide area in Monongalia, Greene, and Washington counties, but is not persistent very far south of the Pennsylvania line."[1]

In Ohio county this sandstone appears to be usually absent, or is replaced by shales; but in the Battle run section a sand-

1. U. S. G. S. Bull. 65, p. 38.

stone is found just below the black slate under the Washington coal, corresponding in position to the Washington sandstone.

There appears to be a rather persistent limestone just below the Washington coal in Ohio county. This limestone is one to eight feet in thickness. In some sections it is under the coal, while in others it is separated by a few feet of shales. The rock is blue in color and usually hard and compact, but in one or two places it was nodular.

The Little Washington Coal.

About 10 to 28 feet below the Washington coal a small blossom is sometimes found, which was named in Pennsylvania the Little Washington coal. It there attains a thickness of one foot, but it is never of economic importance.

This coal is seen just south of Middle Wheeling creek, below the mouth of Ladley run, where it is three inches thick and 15 feet below the Washington coal. It was once mined on a very small scale just east of Point Mills on the Philabaum place, where it is found in a steep ravine 27 feet and 10 inches below the Washington coal and 93 feet above the Waynesburg. At this place the vein is 14 inches thick with a sandstone roof.

The Waynesburg "B" Coal.

This coal is found in Monongalia, Greene, and Washington counties about 45 feet below the Washington coal. It is usually less than a foot in thickness and it is apparently absent or concealed in most of the Ohio county sections, but appears above the Elm Grove shaft 44 feet below the Washington coal.

The Waynesburg "A" Coal.

Dr. I. C. White gives the horizon of the Waynesburg "A" coal at 60 to 80 feet above the Waynesburg coal and describes it as slaty and worthless, though it may attain a thickness of three or four feet.

In Ohio county, on Battle and Dixon runs, this coal is found about 60 feet below the Washington coal and 50 to 70 feet above the Waynesburg coal. It is quite slaty and impure, with a thickness of 10 inches to one foot. Near Elm Grove this coal is found 60 feet below the Washington coal and 40 feet above the Waynesburg.

East of Wellsburg, on the Waynesburg pike, near Fowlersville, this coal shows a local thickness of 30 inches, but no attempt has been made to mine it. The coal is there 44 feet above the Waynesburg coal, as measured with the hand level.

The Waynesburg Sandstone.

The Waynesburg sandstone is described by Dr. I. C. White[1] as "one of the most persistent members of the Dunkard series, since its eastern outcrop can be followed in an almost constant line of cliffs from Greene county, Pa., clear across West Virginia to the Big Kanawha river at Winfield. * * * Along the western border of the outcrop of this rock it dwindles down and changes its character entirely, being frequently represented in Washington county, Pennsylvania; Marshall and Ohio counties, West Virginia; Belmont and Monroe counties, of Ohio, by sandy shales and flaggy sandstones, and occasionally even a stratum of limestone may be found at this horizon."

Near Elm Grove this sandstone is at least 18 feet thick and begins 18 feet above the Waynesburg coal. It may be even thicker as the rocks are concealed for 26 feet above the sandstone on the hill above the Elm Grove shaft. On Chapline Hill, at Wheeling, the interval above the Waynesburg coal includes 25 feet of sandy shales and sandstones. In other sections between Wheeling and Elm Grove the sandstone is replaced by sandy shales.

East of Elm Grove, on Peters run, the sandstone is found 45 feet above the Waynesburg coal and continues with coarse, sandy shales upward for 100 feet. Up Point run, east of Roneys Point, 20 feet of sandstone is exposed above the Waynesburg coal. Along the north side of the National road, between Point Mills and Valley Grove, there is a natural wall of this sandstone. It is also seen 18 to 20 feet thick above the Waynesburg coal north of Glenns run, five miles north of Wheeling. Further north in Ohio county the sandstone appears to be largely replaced by sandy shales.

The Elm Grove Limestone.

Through Ohio and Brooke counties a very persistent limestone is found a few feet above the Waynesburg coal. It varies

1. U. S. G. S. Bull. 65, p. 40.

in thickness from 30 inches to 10 feet and has a deep blue or black color. It weathers into thin shaly layers almost like a slate, which give its outcropping edges a peculiar straited appearance. The limestone in some places rests directly on the coal, but more often is separated from the coal by five to eight feet of shales.

This characteristic limestone was found with the Waynesburg coal in the northwestern part of Marshall county, through most of Ohio and in Brooke county. In no place where the overlying layers of the coal were exposed was the limestone absent. It thus serves as a valuable guide in the identification of the Waynesburg coal, since its appearance is so different from that of the other limestones in the series.

This limestone is well shown near Elm Grove, and east from this town, near the National road, where in the ravines to the south it reaches its maximum thickness, and the writer has therefore named the rock the Elm Grove Limestone.

A sample of this limestone from near Middle Wheeling creek was analyzed in the Survey Laboratory, with the following results, which show it to be a very silicious rock and a very impure limestone:

Lime carbonate	56.61	per cent.
Magnesium carbonate	1.82	" "
Iron and alumina oxides	4.00	" "
Silica	31.20	" "
Water and organic matter	5.79	" "
	99.42	" "

The Cassville Plant Shale.

The shales five to fifteen feet in thickness over the Waynesburg coal have been named by Drs. Fontaine and White the Cassville Plant Shales. In Monongalia county they are found to be rich in fossil plants, many of which are of Permian age. The roof shales of the Waynesburg coal in Ohio county two to five feet thick are apparently non-fossiliferous.

Age of the Dunkard Series.

After a geological examination of the rock strata in several of the provinces of Russia in 1841, Sir Roderick Murchison, the great English geologist, proposed a Permian System to include

the uppermost rocks of the Paleozoic group, the name being taken from the old province of Perm, where these rocks were typically exposed.

This system, known as the Permian or Dyas, was later subdivided in western Europe.

Zechstein	Upper.
Rothliegende	Middle.
	Lower.

The upper or *Zechstein* division consists mainly of limestones and dolomites, while the lower, or *Rothliegende,* is made up of red sandstones, conglomerates, and shales.

In America the existence of Permian rocks has long been a subject of discussion which has resulted in much difference of opinion. The discussion was started in 1857-8 by identification as Permian of a collection of fossils made in Kansas by Hawn and described by F. B. Meek. Meek believed in the existence of the Permian in Kansas as established by the presence of these Permian fossils. This opinion was accepted by such geologists as Swallow, Broadhead, Hayden, Geinitz, and Marcou who claimed to have first suggested the existence of Permian in this country in 1853. The interest in the Permian question apparently ended about 1868 and the problem was considered as unsolved.

In 1885 Dr. Newberry, at the Berlin International Geological Congress is reported as stating, "He had traversed all the States and Territories of the Union and had examined the so-called Permian in many localities, but in his judgment it could not be separated from the Coal Measures."[1]

In 1889 and 1891, the Russian geologist, Tschernyschew, and also Waagen, assigned the beds near Nebraska City, Nebraska, to the Permo-Carboniferous.

In 1890 Prof. W. F. Cummins divided the Permian of Texas into three divisions and named them from the base upward: Wichita, Clear Fork, and Double Mountain beds. From the Wichita, Professor Cope described fossil vertebrates as Permian in age. Dr. I. C. White identified the fossil flora of the Wichita as similar to the flora above the Waynesburg coal in Pennsylvania

1. Quoted by Prosser, Jour. Geol., Vol. III., p. 790.

and West Virginia. Waagen correlated the Wichita with the Zechstein division of the Permian in Europe.[1]

In 1895 Professor Prosser published a classification of the Upper Paleozoic rocks of Central Kansas,[2] and placed his Neosho and Chase formations formerly called Permo-Carboniferous, in the Permian. Professor Prosser has made very careful studies in these formations extending over a period of several years. The result of this work has been the recognition by most geologists of the existence of the Permian system in Kansas and Nebraska. The investigations of Cope, I. C. White and W. F. Cummins have accomplished a similar result in Texas.

In the Appalachian area of Pennsylvania, Ohio, West Virginia, and Maryland the fossil vertebrates are absent in the highest rocks of the Carboniferous, and no extended collections of invertebrates, except insects at one or two localities, have been made. The evidence for Permian strata rests mainly on the fossil flora.

It was in 1880 that Drs. Fontaine and I. C. White published the report of Pennsylvania Geological Survey (PP) on the Permian or Upper Carboniferous Flora of West Virginia and Southwestern Pennsylvania, in which they reached the conclusion that the Upper Barren Measures (later named Dunkard) were Permian in age.

While in this report the authors gave almost conclusive proof for the Permian age of these beds, American geologists seemed adverse to accepting the conclusion.

Fontaine and White determined that "out of 107 fossil plants found in these measures in West Virginia, 22 occur in the Coal Measures proper, while 28 are found also in the Permian of Europe. Of the 22 species which are common to the Upper Barrens and to the Coal Measures below them, 16 are also found in the European Permian, leaving six not hitherto found in the Permian." (p. 111).

Of the 28 species common to the Upper Barrens and the European Permian, 12 have never been found in the Coal Measures of the United States (marked by * in list below) and two are exclusively Permian, namely, *Callipteris conferta* and *Alethopteris gigas*.

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1. Geol. Survey Texas, Vol. IV., p. 225.
2. Jour. of Geol., Vol. III., p. 795.

Species Common Upper Barrens and European Permian.[1]

*Equisetides rugosus.	Pecopteris Candolleana.
Calamites suckowii.	Pecopteris oreopteridia.
*Sphenophyllum longifolium.	*Pecopteris pennaeformis lactifolia.
*Annularia carinata.	Pecopteris Miltoni.
Annularia longifolia.	Pecopteris dentata.
Annularia sphenophylloides.	Pecopteris pteroides.
Annularia radiata.	Pecopteris Pluckeneti.
Annularia minuta.	*Pecopteris Germari.
Neuropteris flexuosa.	Goniopteris emarginata.
Neuropteris auriculata.	Goniopteris elegans.
Neuropteris cordata	*Alethopteris gigas.
*Odontopteris obtusiloba.	Rhacophyllum filiciforme.
*Callipteris conferta.	Rhacophyllum lactuca.
Pecopteris arborescens.	*Sigillaria Brardii.

The authors sum up the evidence for the Permian age of the Upper Barren Measures (Dunkard) as follows:[2]

1. The evidence from the identity of species.
2. The evidence from allied species.
3. The evidence from the decadence of coal measure forms.
4. The introduction of types characteristic of later formations.
5. The existence of an important physical change at the beginning of the Series.
6. The nature of the lithology; the disappearance of coal; the diminution in the amount of plant life.

In 1902 Dr. David White, the well known paleontologist of the United States Geological Survey, re-examined the localities described by Fontaine and I. C. White, and made new collections of the fossil flora. In a paper read before the Geological Society of America at the close of that year he classified the fossils found in the Dunkard Series as follows:[3]

Species Characteristic of Rothliegende or Higher Formations of the Old World.

Callipteris conferta (typical).	Odontopteris obtusiloba
" lyratifolia var coriacea.	Caulopteris gigantea.
" curretiensis.	Equisetites rugosus.
Goniopteris Newberryiana.	Sphenophyllum fontaineanum.
Pecopteris germari.	" tenuifolium.
Alethopteris gigas.	Sigillaria approximata.

1. 2nd Geol. Survey Penn., P. P., p. 105.
2. Ibid, p. 120.
3. Bull. Geol. Soc. America, Vol. 14, p. 539.

Species Closely Allied to Old World Permian Types.

Cymoglossa obtusifolia.
Goniopteris elliptica.
Pecopteris asplenioides.
“ rarinervis.
“ schimperiana.
“ dawsonianum.
Pecopteris odontopteroides.
Alethopteris virginiana.
Odontoperis nervosa.
“ pachyderma.
“ sp. nov.
Neuropteris flexuosa var. longifolia.

Species Whose Habit or Facies Suggest a Late Date (Mesozoic).

Equisetites striatus.
Nematophyllum angustum.
Pecopteris dentata.
“ odontopteroides.
Sphenopteris pachypteroides.
Sphenopteris pachynervis.
Saportaea grandifolia.
Jeanpaulia (Boiera) virginiana.
Taeniopteris newberryana.

Species Which Represent Coal Measure Types.

Pecopteris dentata.
“ emarginata.
* “ elegans.
“ arguta.
“ pennaeformis.
“ arborescens.
* “ oreopteridia.
* “ Miltoni.
“ Candolleana.
* “ pteroides.
* “ Pluckeneti.
* “ grandifolium.
Neuropteris fimbriata.
Neuropteris flexuosa.
“ hirsuta.
“ auriculata.
*Aphlebia filiciformis.
Calamites Suckowii.
Asterophyllites equisetiformis.
*Annularia stellata.
* “ radiata.
“ sphenophylloides.
*Sphenophyllum filiculme.
* “ longifolium.
* “ oblongifolium.
*Sigillaria brardii.

(Species marked * reported in Lower Rothliegende but common in older formations.)

Dr. David White in the above quoted paper (p. 541) concludes from the study of fossil plants so far found in the Dunkard Series that “On account of the small number of species which may be considered as in a measure characteristic of the Rothliegende, the absence from the latter of Callipteris, the old world Dyassic Odontopteris and Callipteridium, and the extreme rarity of the types of later facies, it appears that the beds below the Lower Washington limestone cannot yet be regarded as conclusively referable to the Rothliegende, though they contain a flora which is certainly transitional. The re-enforcement of this flora at the levels of the Washington and Dunkard coals by the more important and distinctly characteristic Rothliegende species mentioned above seems to fully justify the reference of the latter to the Rothliegende, the lower boundary of which may probably be safely drawn as low as the Washington limestone, which is as yet the lowest observed Callipteris horizon. Further search in the floras of the lower beds of the Dunkard and in the Monongahela

is necessary before the Upper boundary of the Coal Measures can be definitely ascertained. The flora of the upper portion of the Dunkard is to be compared with those of the Stockheim and Cusel beds in Germany and of the series in the basin of Brives in France. * * *

"Our highest Appalachian Paleozoic beds do not appear, so far as yet studied paleobotanically, to extend above the Lower Rothliegende of western Europe. The Zechstein, if originally present, as seems not unlikely, has long since disappeared. The reference of the greater part of the Dunkard to the Lower Rothliegende appears to be well founded; but it seems to the writer as probable that the plants of the Upper Dunkard or of the lowest of the terraces of western Europe that are now generally classed as Rothliegende are hardly of so late a date as the flora of the Artinsk stage of Russia."

The conclusions of Dr. David White agree for the most part with those of Fontaine and I. C. White and give additional weight to the belief in Permian age of the Dunkard Series.

Professor Prosser in a recent review of the question of the Permian age of the Dunkard Series writes,[1] "A number of European geologists have accepted Permian as the age of the Dunkard formation, and Dr. Frech states that the Dunkard Creek beds and Cassville plant shale, the latter of which is the shale at the base of the Dunkard formation immediately overlying the Waynesburg coal, are the equivalent of the Cusel stage, which is the oldest division of the Lower Rothliegende of Germany. And in another sentence is the statement that the petrographical and paleontological similarity of the Dunkard with the Rothliegende of Western Europe is therefore beyond doubt. Dr. Kayser also puts the Dunkard in the Permian, and he has made the following statement concerning its age: In the United States we find in the east (Virginia, Pennsylvania, etc.) in conformable layers upon the upper Carboniferous the so-called Barren Measures with *Callipteris conferta, Taeniopteris* and other Permian characteristic forms together with typical Carboniferous plants as representative of the Permian."

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1. Geol. Survey of Ohio, Bull. No. 7, Revised Nomenclature of the Ohio Geological Formations, p. 6, 1905.

Professor Scudder published descriptions of the fossil insects found in the Cassville shales in Bulletin 124, U. S. Geol. Survey. He states that this fauna is unquestionably younger than any known from the Pennsylvania or Illinois rocks. Fifty-six species were described, belonging to five genera, but thirty-six of them were of one genus, *Etoblattina.*

The only occurrence of a similar form to many of these species (25 per cent) of Etoblattina and Gerablattina, Professor Scudder says, is the *Etoblattina elongata* from the Lower Dyas of Weissig, Saxony. The genera described by Professor Scudder from the Cassville shale are, Etoblattina with 36 species; Poroblattina, three species; Petrablattina, one species.

With the evidence now available and the opinions of able scientists who have made special study of the Permian problems, there would seem to be little ground for doubting the Permian age of a large portion of the Dunkard, if not all. The fossil plants in the upper portion of the series certainly indicate a Permian age, and the fossil insects in the lowest part would indicate these strata to be Permian.

Fossil Plants From the Dunkard Series in Ohio Co., W. Va.

The roof shales of the Washington and Dunkard coals in Ohio county usually contain a large number of fossil leaves, but in the same locality they show considerable uniformity in characters. A number of these fossils were collected in the vicinity of Valley Grove, Ohio county, and sent to Prof. William M. Fontaine, of the University of Virginia, who has kindly examined them. The following fossil plants were identified by Professor Fontaine from this material, and his comments on the forms are included:

The specimens from the shales ten feet below the Washington coal on the Taggart farm, on McGraw's run, one-half mile west of Valley Grove, show the following types:

Pecopteris tenuinervis.
Pecopteris platynervis.
Neuropteris flexuosa.
Equisetides elongatus? obscure imprint.

Practically all the plants here are *Pecopteris tenuinervis* and *Pecopteris platynervis,* the former predominates and both show

some good specimens. They occur mostly in forms with pinnules of smaller size than the average. *Neuropteris flexuosa* occurs in only three obscure imprints, and the fossil suggesting *Equisetides elongatus* in only one doubtful form. This confirms the deductions drawn in the Pennsylvania Geological report PP., viz.: that the Upper Barren (Dunkard) flora is noteworthy for the very few species found at each locality, these, however, being represented by many individuals for the predominating forms.

The roof shales of the Washington coal one-half mile south of Valley Grove yielded the following fossils:

Neuropteris flexuosa.

A Neuropterid pinnule apparently rachial.

Nearly all the fossils at this locality are *Neuropteris flexuosa*. They are very numerous. A few pinnules of much larger size occur, but they are imperfectly preserved and do not show full character. These pinnules have a divergent, cyclopteroid nervation, and they are probably the clasping rachial pinnules of Neuropteris flexuosa.

From the roof shales of the Dunkard coal on the Atkinson farm, one mile and a half east of Valley Grove, the following plants were identified:

Neuropteris odontopteroides.

Neuropteris hirsuta.

Neuropteris flexuosa.

Neuropterid rachial pinnules, probably of Neuropteris hirsuta?

Alethopteris gigas.

Calipteridium oblongifolium.

Strap shaped imprints of epidermal tissue, suggesting a plant of Calamitean affinity.

Imprints of woody stems.

This locality is richer in species than any of the others, and it seems to be a promising one for furnishing a representation of the flora of the higher horizons of the Upper Barrens (Dunkard).

There are several impressions of *Neuropteris odontopteroides*, but the plant is rare, and the same may be said of *Alethopteris gigas*. *Callipteridium oblongifolium* is next to Neuropteris hirsuta the most common, and it is generally in fructified forms. *Neuropteris hirsuta*, the most common form, occurs in a great

number of detached pinnules, mostly fragmentary. Neuropterid rachial pinnules occur here also, that probably belong to Neuropteris hirsuta, but they are larger and coarser with stronger nervation than those found in the roof shales of the Washington coal one-half mile south of Valley Grove. *Neuropteris flexuosa* occurs here in only two or three small fragments of pinnæ. Several imprints of epidermal tissue and of woody stems occur, but they do not show definite characters.

The roof shales of the Washington coal south of Roneys Point on Point Run give a few poor specimens of the *Neuropteris flexuosa,* and in the pipe line ditch near Reeds Mill these roof shales give four good imprints of *Pecopteris tenuinervis.*

Over the Dunkard coal in the railroad cuts one mile and a half east of Valley Grove were several imprints of *Neuropteris flexuosa* and *hirsuta.*

CHAPTER IV.

THE MONONGAHELA SERIES.

This series was named by Prof. H. D. Rogers many years ago on account of the great development of its coal seams along the Monongahela river. The series extends from the base of the Pittsburg coal to the roof shales of the Waynesburg coal, an interval varying in thickness from 263 feet along the Ohio river to 400 feet near the interior of the Appalachian basin.

Dr. I. C. White gives the following description of this series in Volume II of the reports of the West Virginia Geological Survey (pp. 124-125):

"In the northern part of the State nearly one-half of the rock material composing the Monongahela series is limestone, red shales are unknown, while massive sandstones are seldom found except along the eastern side of the Monongahela outcrop. The disintegration of these limestones, limy shales and other soft rocks at the north, gives origin to a gentle topography and an extremely fertile soil, thus forming in Monongalia, Marion, Harrison, Lewis, Marshall, Ohio and Brooke counties, as well as in portions of Upshur, Barbour, and Taylor the finest agricultural and grazing regions in the State.

"In passing southwest from Harrison, Taylor, and Lewis counties, however, the limestones practically disappear, along with most all of the coal beds, while red shales come in as the limestones go out, apparently replacing the latter, and the sandstones grow more massive than in the northern area, thus giving origin to a rugged topography and less fertile soils.

"These rocks extend over a wide area along the Ohio river and for many miles south of it, as far as the Great Kanawha, and in a narrow belt from that point to the Big Sandy, where in the center of the Appalachian trough, the lowest of these beds passes into the air before reaching the Kentucky line.

"No marine fossils have ever been discovered in any of the limestones of the Monongahela series, and everything indicates

that the deposits are of fresh water origin. The black slates always contain fish remains in the shape of scales and teeth, but nothing is known of their affinities, because they have never been studied. The water may have been estuarine and slightly brackish, but the minute Cyprian and Estherian-like forms whose skeletons—mostly broken and pulverized—make up the principal mass of the Monongahela limestones, testify clearly against their marine origin."

The rock strata of the Monongahela Series were first studied in detail in Pennsylvania, and the names given to these formations are for the most part taken from localities in that State.

Dr. John J. Stevenson in the Second Geological Survey of Pennsylvania (K. K., p. 31) gives the following general section of the Monongahela Series in Fayette and Westmoreland counties:

Section in Fayette and Westmoreland Counties, Pa.

	Ft.
Coal, Waynesburg	6
Sandy shales or sandstone	20
Coal, Little Waynesburg	2
Limestone, Waynesburg	20
Shale and shaly sandstone	50
Coal, Uniontown	3
Limestone, Uniontown	12
Sandstone	30
Limestone, "Great"	80
Coal, Sewickley	3
Sandstone	30
Limestone, Sewickley	25
Shale or shaly sandstone	20
Coal, Redstone	4
Limestone, Redstone	10
Sandstone or shale	40
Coal, Pitsburg	12
	367

Another typical section of the Monongahela Series in West Virginia is given by Dr. I. C. White as measured on Robinson's run, in Monongalia county, two miles west of the Monongahela river:[1]

Section Along Robinson's Run, West Virginia.

	Ft.
Coal, Waynesburg	8
Sandy shales, iron ore below middle	35
Limestone, Waynesburg	8
Shales	10
Limestone	1
Sandstone, flaggy	40

1. U. S. G. S. Bull. 65, p. 46.

Black slate (Uniontown coal)	5
Limestone, Uniontown	10
Sandstone and shales	35
Limestone	6
Shales	10
Sandstone, flaggy	30
Limestone, cement beds	20
Sandstone, Sewickley	35
Coal, Sewickley	5½
Shales	10
Limestone	10
Shales	12
Limestone	18
Shales	15
Coal, Redstone	4
Limestone, Redstone	10
Shales and slates	20
Coal, Pittsburg	12
	369½

One more section is given to illustrate the Monongahela Series in Ohio. This section was carefully leveled near Bellaire, Ohio, by the late Prof. C. N. Brown of the Ohio Geological Survey:

Section Near Bellaire, Belmont County, Ohio.

	Ft.
Coal, Waynesburg	2
Shales, sandy	6
Shales	12
Limestone	3
Concealed	5
Coal blossom, Little Waynesburg	0
Concealed	14
Coal blossom, Uniontown	0
Shales	4
Sandstone	6
Shale, argillaceous	20
Concealed	32
Shales	2
Sandstone	3
Shales	3
Concealed	33
Calcareous shale with thin limestone	24-6
Coal and shales, Sewickley	27-6
Shales, agillaceous	2
Limestone, thin clay in center	8
Limestone, magnesian, cement rock	5
Clay	1
Limestone	11
Concealed	11
Coal blossom, Redstone	2
Concealed	17
Shales	1
Coal, Pittsburg	17
	263

The sections given on pages 39 and 40, which were measured in Ohio county, on Chapline Hill, at Wheeling, and one mile and a half east up the ravine opposite Carter's run, gives 261 feet 8 inches as the thickness of the Monongahela Series in this area. The Waynesburg coal is 189 feet, 10 inches above the Sewickley, and the interval between the Sewickley and Redstone coals is 33 feet, while the Redstone coal comes 28 feet above the Pittsburg.

At Elm Grove the Waynesburg coal is 196 feet, 4 inches above the top of the coal shaft in which the bottom of the Pittsburg vein is reached at 65 feet, giving a thickness of 261 feet, 4 inches, for the Monongahela Series, an interval agreeing closely with the Chapline Hill section, and the one at Bellaire, Ohio, quoted above.

One mile east of Elm Grove, on Peters run, the Creighton slope mine reaches the Pittsburg coal, while the Waynesburg coal is found in the hill above. The following section was measured with hand level from the bottom of the mine to the Waynesburg coal:

Creighton Slope Mine and Hill Section.

Coal blossom, Waynesburg	2			
Shales, sandy	7	8		
Limestone, gray	2			
Concealed	46	8		
Limestone, gray, nodular, Uniontown(?)	3			
Sandstone	4			
Concealed and sandy shales	60			
Limestone, blue	10	4	256	8
Concealed	25	10		
Coal, Upper Sewickley	2			
Top of Slope Mine.				
Shales	22			
Coal, Lower Sewickley	2			
Limestone and shales	64			
Pittsburg coal	5			

The thickness of the Monongahela series in this section is a few feet less than at Elm Grove and Wheeling. The Sewickley coal is divided into two divisions, an upper and lower, separated by 22 feet of shales. This division of the Sewickley is found at Triadelphia and other points along Middle Wheeling creek.

In the section made on Chapline Hill this division of the Sewickley was not found, but on the west side of the same hill

the two coals occur on the farm road, the upper division being 10 inches thick and the lower 4 inches, separated by 10 to 12 feet of shales.

In Creighton slope mine the Redstone coal is apparently absent, and this is true in some of the Chapline Hill sections.

At Triadelphia, near the Knight coal bank, the Sewickley coal occurs in two divisions 14 feet, 6 inches apart and both seams of good thickness. The Waynesburg coal is 190 feet, 2 inches, by hand level above the Lower Sewickley, which lies in the bed of the creek. If the interval from this coal to the bottom of the Pittsburg is the same as in the Creighton mine, the thickness of the Monongahela Series at Triadelphia would be 261 feet.

At Fulton, on Wheeling creek, one-half mile north of Wheeling, the following section was measured, which gives 260 feet for the Pittsburg-Waynesburg interval:

Fulton Section.

		Ft.	In.	Ft.	In.
Waynesburg coal		2	6		
Shales and concealed		30			
Limestone, Waynesburg		6			
Shales, buff		3			
Limestone and shales		15			
Shaly sandstone		15			
Concealed		28			
Green shale, Fulton		2			
Limestone, Benwood		60			
Shales		12			
Black slate, Sewickley		1	6		
Concealed		22		258	6
Shales, buff		8			
Sewickley	Limestone, solid	6			
	Limestone, brecciated	2			
	Limestone	12			
Shales, gray		3			
Coal, Redstone		0	6		
Shales, clay		2			
Limestone, shaly		2	6		
Limestone, Redstone		17			
Shales		3			
Pittsburg coal		5	6		

In Brooke county, just south of Wellsburg, the lower portion of the Monongahela series is exposed, but the hills near the river are not high enough to reach the Waynesburg coal:

Wellsburg Section.

			Ft.	In.
Shales, sandy, and sandstone layers from hill top	50			
Concealed shales and limestone	85			
Limestone, Uniontown	2+			
Shales	6	9		
Coal blossom, Upper Sewickley	0	3		
Shales	6	9	233	4
Black slate, Lower Sewickley horizon	0	4		
Concealed and limestone	49			
Coal, Redstone	0	6		
Limestone, Redstone	9	9		
Concealed and limestone	18			
Pittsburg coal	5			

This section gives an interval of nearly 28 feet between the Pittsburg and Redstone coals, with the Upper Sewickley coal 56 feet higher. Farther east the interval between the Pittsburg and Waynesburg coals is 242 to 255 feet.

Up Waddles run, near the Brooke county line the following section was measured, giving 255 feet for the thickness of the Monongahela series:

Waddle's Run Section.

	Ft.	In.	Ft.	In.
Coal blossom, Waynesburg	2			
Concealed and sandy shales	81			
Green shale, Fulton	2	6		
Limestone and shales, Benwood	75			
Shales	15		255	2
Coal blossom, Sewickley	0	8		
Concealed and limestone	22			
Sandstone	3			
Limestone and concealed	50			
Pittsburg coal	4			

Near Bethany the interval between the Pittsburg and Redstone coal varies from 26 to 28 feet, 4 inches, and the Sewickley 4 inches thick is found 60 feet, 6 inches higher, the Monongahela Series having a total thickness of 255 feet.

On Hoglan run the section measured with the hand level appears to be shorter than the average thickness in the Buffalo creek area, although the lower divisions of the series are separated by average intervals. The section was carried about a quarter of a mile along the southeast dip, which would make the intervals somewhat shorter than they would be in vertical section.

Hoglan Run Section.

	Ft.	In.	Ft.	In.
Coal blossom, Waynesburg	1+			
Concealed and shales	58	5		
Sandstone	8			
Concealed	62			
Limestone	2+			
Shales	12		242	1
Coal blossom, Sewickley	0	6		
Concealed	63	7		
Coal blossom, Redstone	0	5		
Concealed and limestone	20			
Shales	10	4		
Pittsburg coal	3	10		

The farthest north the interval between the Waynesburg and Pittsburg was measured is on the ridge near Fowlersville, three and a half miles east of Wellsburg. The interval on the south side is 225 feet by barometer and on the north side as measured with the hand level is only 216 feet, 4 inches. The Pittsburg coal was found in a mine near the Pennsylvania State line and had the characteristic structure with roof coal above. The heavy blossom on the hill above had the characteristic Elm Grove limestone over it, with the blossom of Waynesburg "A" 18 inches thick and 42 feet higher. There can be very little doubt as to the proper identification of the coals.

One mile and a half farther north the interval from the Waynesburg coal to the Pittsburg at the Rex mine is 230 feet, but this mine is about 35 to 40 feet lower than the mines to the east and north. If any allowance is made for dip, the interval at the Rex mine would be about 250 feet and at the other mines about 215 feet.

DESCRIPTION OF THE FORMATIONS.

The following formations are included in the Monongahela Series and their total thickness in the Pan Handle area is 260 feet:

Waynesburg coal.
Little Washington coal.
Waynesburg limestone,
Gilboy sandstone.
Uniontown coal.

Uniontown limestone.
Fulton green shale.
Benwood limestone.
Sewickley sandstone.
Upper Sewickley coal.
Lower Sewickley coal.
Sewickley limestone.
Redstone coal.
Redstone limestone.
Upper Pittsburg sandstone.
Pittsburg coal.

The Waynesburg Coal.

The highest formation in the Monongahela Series was named by H. D. Rogers the Waynesburg coal, from Waynesburg, county seat of Greene county, Pa., near which place the coal has been mined for many years. In the former coal nomenclature of Ohio it was the Number 11 seam.

According to Dr. I. C. White,[1] "The seam is always multiple bedded, being generally separated into *roof, upper,* and *lower* divisions, by shale and fire clay partings, the whole often nine to ten feet in thickness. This coal appears to attain its maximum thickness and importance in Marion and Monongalia counties, and the adjoining region of Greene county, Pennsylvania, since it thins down in every direction when traced away from these regions.

"The coal is always high in ash and moisture, and hence is a poor steam coal, and is used for that purpose only when nothing better is accessible. Of course there is always some good coal in the bed, but it is generally mixed up with the poorer quality in mining and the resultant fuel is never of first grade."

This coal has been the main source of supply in Greene county, Pa., and can be traced in all directions from this area. In Maryland it was named the Koontz vein, and varies from 5 feet 9 inches in thickness, with the following structure:[2]

1. W. Va. Geol. Survey, Vol. II., p. 147.
2. Md. Geol. Survey. Allegany County Report, p. 180.

	Ft.	In.
Coal	2	3
Bone		4
Coal		6
Bone		7
Coal	1	3
Slate		10
Coal		5
Shale	0	0
	6	2

Its position in this area, according to the Maryland Survey is 230-250 feet above the top of the Pittsburg.

In Washington county, Pa., according to Dr. Stevenson, the extremes of thickness of the Waynesburg coal are 6 inches and 7 feet, with abrupt variations even in a single township. He gives the following section as a typical form in a 5½-foot bed:[1]

Coal	5 to 16 inches
Clay	10 to 18 "
Coal	27 to 34 "
Clay	4 to 20 "
Coal	5 to 7 "

In Franklin township, Greene county, Pennsylvania, he finds the bed six feet thick to be double:

Coal	12 to 18 inches
Clay	12 to 48 "
Coal	12 to 42 "

In Cass district, Monongalia county, this coal has the following structure, according to Dr. White:

	Ft.	In.	Ft.	In.
Coal	4	5		
Impure fire clay	0	8	9	4
Coal	4	3		

Near Moundsville, where the coal is 275 feet above the Pittsburg the structure shows:

	Ft.	In.	Ft.	In.
Coal, bony	0	6		
Impure fire clay	1	0	3	
Coal, slaty	1	6		

In Ohio county, near Point Mills, the structure is:

	Ft.	In.
Coal	3	0
Clay	1	2
Coal	0	3

1. 2nd Geol. Survey of Penn. Report K., p. 59.

Further north, near Potomac, at the Hinerman bank the coal has a similar structure:

	Ft.	In.
Coal	1	2
Shale	0	1
Coal	0	10

The Waynesburg coal is mined for local use at a number of places along the National road, in Ohio county, near Point Mills, near the mouth of Battle and Dixon runs, east of Roney's Point on Point run, one mile south of Triadelphia, and old mines are found in the vicinity of Twilight. The thickness of two and a half feet is quite constant in all these mines, but the parting near the center decreases to a fraction of one inch, and in some mines appears to be absent.

Dr. Stevenson in 1875 traced this coal from Washington county, Pennsylvania, across Ohio county and into the State of Ohio, and stated:[1]

"The upper bench soon disappears and in the Pan Handle to the Ohio river, the bed is single." In the detailed study of the Waynesburg coal in Ohio county, the shale parting in the coal appears to decrease in thickness from 14 inches to a fraction of one inch from Point Mills to Roneys Point, and in places is entirely absent, suggesting that this parting between the upper and lower benches disappears, leaving a single bench, which represents the union of the upper and lower benches, rather than the complete disappearance of one.

In Belmont county, Ohio, the Waynesburg coal (No. 11), according to Dr. Stevenson, is still subject to the sudden changes as illustrated by the following description:[2] "In the second cut west from Barnesville, on the Central Ohio railroad, it varies from six inches to nearly six feet within one hundred yards. In this portion of the county it is known as the 'Jumping six-foot vein.' * * * It is rarely of any economical value, and at no locality does it yield good coal."

The blossom of the Waynesburg coal and roof slate, two to three feet thick, usually with the Elm Grove limestone exposed above, is found through Ohio county and southern Brooke, disappearing about one mile south of Cross creek, where it is repre-

1. 2nd. Geol. Survey of Penn. Report K., p. 61.
2. Ohio Geol. Survey, Val. III, p. 264.

sented by small outliers near the top of the hills. It occurs as a long narrow belt following the high ridge road of the Waynesburg pike from the Pennsylvania line west to within two miles of Wellsburg. Near the State line, in artificial excavations, it is reported to be three to three and one-half feet thick.

The Waynesburg coal is mined in the northeastern part of Ohio county, opposite the mouth of Curtis run, one mile south of Potomac, where the coal is two feet thick with the clay parting one inch, nine to ten inches from the bottom. The roof is an eight-inch layer of sandstone with shales above.

The farthest north this coal is mined is on the ridge one mile east of Beach Bottom and two and a half miles south of Wellsburg. The coal at this mine has the following structure:

	Ft.	In.	Ft.	In.
Gray and black shale roof	1			
Gray shale	0	8		
Bone coal	0	4		
Coal	2			
Slate parting	0	1	3	11
Coal	1	6		
Shale floor.				

The Elm Grove limestone crops just above this section, and the coal has the greatest thickness of any mine operated in the two counties.

The Waynesburg coal with its small thickness and poor quality will probably never be of much economic importance in this area until the great Pittsburg seam is exhausted. It is better than any coal above it, and there is no coal to compete with it below for 180 feet until the Sewickley is reached. It is more regular than the Sewickley in this area, and holds its workable thickness over a larger area.

The Waynesburg coal furnishes a convenient supply of fuel for the farmers on whose land it occurs, and also supplies a local trade. The introduction of natural gas through the county has interfered with the working of these small local banks, and many have been abandoned on that account. The mines are small, employing two or three miners at the most in each, and are only worked through a portion of the year.

This coal is a good guide in estimating the depth of the Pittsburg seam, 240 to 260 feet lower. The outcrop has been placed on the economic geological maps which accompany this report.

The chemical composition of this and the other coals will be discussed under the chapter on economic resources of the Pan Handle counties.

The Little Waynesburg Coal.

From ten to twenty feet below the Waynesburg coal in Pennsylvania a thin coal is sometimes found which was named by Dr. J. J. Stevenson the Little Waynesburg coal. This coal is not of any economic importance and has not been identified in the Pan Handle area, unless the black slate six feet below the Waynesburg on Chapline Hill represents this horizon. In the section opposite Carter's run a similar black slate was noted 36 feet below the Waynesburg black slate.

The Waynesburg Limestone.

About 20 to 40 feet below the Waynesburg coal and under the Little Waynesburg is often found a gray limestone, named the Waynesburg. According to Dr. White, "The thickness in Pennsylvania and northern West Virginia is seldom less than eight feet, and frequently double that, but southwestward, toward the Great Kanawha region, the limestone disappears entirely."[1]

In Ohio county in the Chapline Hill section a gray limestone is seen 16 feet below the Waynesburg coal. While this stratum is only two feet thick, it may represent this limestone. Limestone and shales occur at this horizon opposite Carter's run. On the hill above the Elm Grove shaft a similar limestone occurs 40 feet below the Waynesburg. At Fulton a limestone six feet in thickness is found 30 feet below the coal. This limestone in the Monongalia county section on Robinson's run is 35 feet below the Waynesburg, and is there eight feet thick. The measurement at Fulton shows the greatest thickness of this stratum, while the average in Ohio county is two to three feet.

The Gilboy Sandstone.

According to Dr. I. C. White (Vol. II W. Va. Geol. Survey, p. 150), "Very frequently, and especially along the eastern crop of the Waynesburg coal, a great sandstone mass comes into the sec-

1. U. S. G. S. Bull. 65, p. 58.

tion at five to ten feet below the coal, cutting out the Little Waynesburg coal and its underlying limestone completely."

This sandstone is prominent in the Gilboy cut on the Baltimore & Ohio railroad just east from Mannington. This horizon in Ohio county is usually occupied by sandy shales and shaly sandstone. The solid sandstone is apparently absent.

Dr. White states in the report quoted above that: "The stratum is a very hard, rather fine grained, grayish white rock, seldom containing any pebbles, and when present forms bold cliffs or bluffs below that of the Waynesburg pebbly sandstone above. It is especially prominent in Marion, Lewis and Gilmer counties." This stratum was not identified in the Pan Handle area, where it is probably absent.

The Uniontown Coal.

At an interval of 90 to 125 feet below the Waynesburg coal, another vein is found in Pennsylvania which was called the Uniontown coal. According to Dr. I. C. White, (Vol. II, W. Va. Geol. Survey, p. 150). "It is seldom more than three feet thick, often only two, and sometimes represented merely by black slate, so that from an economic standpoint it is of little present value, since in most cases it is rather high in ash and other impurities." This stratum also appears to be absent in the Ohio county sections unless possibly the clay blossom 8 inches thick and 48 feet below the Waynesburg coal represents this horizon.

The Uniontown Limestone.

The interval between the Uniontown and Sewickley coals containing limestone and limy shales was named the Great Limestone by the first Pennsylvania survey. It was later divided by Stevenson into two divisions: the *Upper*, 6 to 18 feet thick, lies under the Uniontown coal and is distinguished by its bright buff color from the *Lower* division, which is 50 to 90 feet thick, and of variable character.

Dr. Stevenson gives the following description of the Lower division of the Great Limestone in Pennsylvania:[1]

"The lower portion is commonly more or less magnesian, breaks with a smooth surface which is sometimes lustreless, while

1. 2nd Geol. Survey of Penn. Report K p. 64.

at others it is quite bright. This part is employed for the manufacture of cement at many places, and is available throughout eastern Washington county. It is the more persistent part of the mass, having been identified in Allegheny county on the Pittsburg and Steubenville pike. When exposed to the weather it eventually breaks up into small angular fragments. Its thickness is sometimes fully 50 feet, nearly all of which is limestone. The relative proportion of shale increases northward, and in Allegheny county the shale seems to predominate. This portion is wholly *non-fossiliferous* except in a thin layer at the base. The upper portion contains every variety of limestone, from that pure enough for the manufacture of lime, to that which is utterly worthless for any purpose whatever."

Dr. Stevenson further states that the upper division is absent in Ohio, while the Lower division varies in thickness from zero to 70 feet north from the Central Ohio (B. & O.) railroad, and rests directly upon the Sewickley coal. As the limestone is followed southward in West Virginia it thins out, and at the Little Kanawha river is represented, according to Drs. Stevenson and White, by only thin argillaceous limestones, while twenty miles farther south no trace of it exists.

Dr. I. C. White has named the Lower division of the Great Limestone, the Benwood, from Benwood, West Virginia, where there are excellent exposures of the rock; and limits the name Uniontown to the Upper division.

In the Ohio county area, where the Uniontown coal is absent, there is found a very persistent bed of green shale at a horizon 80 to 100 feet below the Waynesburg coal, and 80 to 90 feet above the Sewickley. There is a marked contrast in the limestone above and below this shale, but the characters of the rock agree closely with those given by Stevenson for the Lower and Upper divisions of the Great Limestone in Pennsylvania. In the present report this green shale is taken as the dividing horizon between the Upper or Uniontown limestone, and the Lower, or Benwood.

The limestone above the green shale is hard, blue rock, one to two feet thick, resting directly on the green shale or a short distance above. Then comes a series of sandy lime layers buff to brown in color, and shaly. These calcareous shales finally pass into typical buff shales with thin sandstone layers and in places thin limestone strata. Their thickness varies from 20 to 50 feet.

In the Ohio county area it is difficult to determine accurately the upper limit of the Uniontown limestone with its calcareous shales. Where the Uniontown coal or black slate is present this limestone would extend to that horizon.

The structure of the Uniontown limestone in this area is well exposed in the B. & O. railroad cut at Roney's Point, which shows:

	Ft.
Shales sandy from top of hill	12
Nodular limestone	2
Calcareous sandy shales	10
Limestone	2
Shales, buff	10
Limestone	2
Shales, buff	6
Limestone	2
	46

The Fulton Green Shale.

The stratum of green shale 80 to 90 feet above the Sewickley coal, is very persistent through Ohio county and is especially well developed in the Wheeling area, where it is 2½ to 5 feet thick. Its geological horizon is clearly shown in the Fulton section, and the name Fulton Green Shale is therefore proposed for this stratum. In fresh exposures, it is a bright green, finely laminated shale, but weathers to a bluish green. It has been found near Clinton, West Liberty, Wellsburg, and north to within a half mile of Cross creek.

The Benwood Limestone.

The limestone below the Fulton Green Shale forms vertical cliffs along Wheeling, Middle Wheeling, Little Wheeling, and Short creeks. It consists of solid layers alternating with shaly layers. The rock weathers in a very characteristic manner into angular fragments, giving the layers a complex fractured appearance as though broken by some sudden shattering force. It is this property of weathering into small fragments which soon break off that explains the vertical walls.

Along the National road east of Elm Grove these steep cliffs of grayish white limestone, 20 to 60 feet in height, are conspicuous features in the topography. Back from the creeks this horizon even when covered with vegetation forms a steep slope closely

Plate V.—Benwood Limestone on Wheeling Creek Near the Ohio—Marshall County Line.

approaching the vertical, so that this limestone is an important factor in the topography of the districts where it occurs.

The limestone on fresh fracture is blue to black in color, but weathers to a light gray or buff. The lower layers are buff in color, breaking with a smooth almost slaty fracture, and are locally known as the cement beds or cement rock. In past years this portion of the limestone was burned for natural cement, but never on an extensive scale in this area. Both the lower and upper layers have been quarried for road material. It is popular with the workmen for this purpose as the rock can be easily quarried and readily broken with very little effort. When spread on the roads it soon breaks and crumbles to smaller and smaller pieces until it forms a dust.

Near Benwood the limestone forms a cliff about 30 feet in height. The shaly layers weather more rapidly than the solid, thus leaving slightly projecting layers which give the surface of the cliff an undulating or wavy outline. The compact strata have their exposed edges traversed by the network of seams caused by weathering. As these fissured blocks break off and fall to the base of the cliff they leave freshly exposed surfaces of blue or black color between the light buff or gray weathered surfaces, thus giving a very peculiar spotted appearance to the cliff.

It was from this locality that the name Benwood was selected for this limestone. Wherever this rock is exposed in the Pan Handle area the appearance of the cliffs is similar to those at Benwood. There is thus a marked contrast between the Benwood and Uniontown limestones, so that the two can be readily distinguished even where the Fulton green shale is absent or concealed.

The Benwood limestone is 30 to 60 feet in thickness. Good exposures of the rock may be seen at the Cedar rocks near the Ohio-Marshall county line above Patterson on Wheeling creek, (illustrated in plate V), on the hill above the Wheeling Terminal railroad tunnel near Fulton, below Twilight on Middle Wheeling creek, and between Triadelphia and Roney's Point, along Little Wheeling creek and on the National road, along the river bluffs from Wheeling to Benwood, on North Fork of Short creek from a mile southwest of West Liberty to Shannon, and along many of the smaller creeks in the eastern part of Ohio county and in Brooke.

The following section was made of the Benwood limestone one mile and a half west of Twilight on Middle Wheeling creek and shows the typical structure of the formation:

	Ft.	In.
Limestone, solid	2	
Fulton green shale	3	
Limestone, shaly	6	
Limestone, solid	2	
Limestone, shaly	0	6
Limestone, solid	2	6
Limestone, shaly	3	
Limestone, solid	1	
Limestone, shaly	3	
Limestone, solid	1	6
Limestone, shaly	2	
Limestone, solid	1	
	27	6

An average sample of the above layers below the Fulton green shale was analyzed, and showed the Benwood limestone in this area to be an impure rock, high in silica and alumina, and magnesian. This analysis when compared with one made from the lower portion of the formation, or the cement rock on Scott's run in Monongalia county, shows it to be much more impure. The lower beds in this area were not analyzed but they have the appearance of a magnesian limestone.

Analyses of Benwood Limestone.

	Near Twilight.	Scott's Run.
Lime carbonate	47.34	86.70
Magnesium carbonate	17.69	5.32
Silica	22.22	5.96
Alumina	8.57	1.06
Iron oxide	2.01	1.27
Titanium	0.21	0.07

The Sewickley Sandstone.

Along the eastern outcrop of the Monongahela Series, according to Dr. I. C. White, a massive sandstone frequently comes into the section and cuts out all or a large portion of the Benwood and Uniontown limestones. When present this sandstone overlies the Sewickley coal and was named by Dr. White the Sewickley sandstone. It is well exposed along the Monongahela river between Morgantown and Fairmont, reaching 60 feet in thickness. This same sandstone was found in Maryland by Mr. Geo. C. Martin

with a minimum thickness of 15 feet, and the Great limestone is entirely absent.

In Ohio county, West Virginia, when the Benwood limestone is found directly over the Sewickley coal the interval includes a belt of shales, and no well defined sandstone stratum was observed.

The Sewickley Coals.

At 70 to 100 feet above the base of the Monongahela series is a coal seam of wide distribution, named by the first Geological Survey of Pennsylvania the Sewickley coal.

In Pennsylvania, according to Dr. Stevenson, this coal is available only in the southeastern portion of Greene county, being too thin elsewhere to be of any value.[1] Further north it is frequently represented by a bituminous shale, and in Allegheny county could not be identified.

Near Mapletown, in Greene county, the coal is mined under the name of the "Mapletown coal," a name which is sometimes used locally for the same coal in Ohio and Marshall counties, W. Va. Dr. Stevenson gives the typical structures of the coal in Greene county as:

	Ft.	In.
Coal	2	1
Clay	0	1
Coal	3	4
	5	6

Its character is variable and its thickness varies from zero to six feet. The coal is a valuable seam in Marion and Monongalia counties, West Virginia, where the coal has the following character, according to Dr. I. C. White (W. Va. Geol. Survey, Vol. II, p. 154): "The coal has a fine reputation for domestic use among the farmers of Marion and Monongalia, who generally prefer it to the Pittsburg coal below on account of its more open burning and less fusing character in the grate. The coal is usually interlaminated by thin layers of mineral charcoal, and this structure causes it to burn with a bright flame, leaving only a fine ash with little clinker, although it carries more ash and sul-

1. 2nd Geol. Survey of Penn. Report K, p. 65.

phur than the Pittsburg coal below.. The coal is rather too hard to coke well without crushing and washing, but it mines in large blocks with no more fine coal than the Pittsburg, and bears transportation equally well.

"The coal when possessing its normal thickness of five to six feet, is generally split into two members by a layer of slate one to three inches thick near the center, and sometimes one or both members may be again sub-divided by one or more thin slates."

The Sewickley coal near Farmington, Marion county, has the following structure, according to the report quoted above:

		Ft.	In.	Ft.	In.
Upper bench	Coal	0	9	2	7¼
	Slate	0	¾		
	Coal	0	6		
	Slate	0	½		
	Coal	1	3		
Slate				0	1
Lower bench				3	4
				6	¼

This section shows the two benches of the coal with the upper one sub-divided. On Robinson's run, in Monongalia county, the structure is similar to that in Greene county, Pa.

	Ft.	In.
Coal, upper bench	2	6
Slate	0	½
Coal, lower bench	2	6
	5	½

In the Georges Creek basin of Maryland the Sewickley coal is separated into two seams, 45 feet apart, and named the Upper Sewickley or Tyson, and the Lower Sewickley. The Lower is a thin seam, while the Upper has been known as the Tyson or "Gas" coal.

According to the Maryland Geological Survey,[1] the Upper Sewickley or Tyson vein has been worked from time to time but the results have not been very satisfactory. According to this report, "The vein varies from 4 feet 7 inches to 7 feet 3 inches in thickness. The coal is moderately clean but in other respects is inferior to the Big Vein coal (Pittsburg) in quality. Like the Big

1. Md. Geol. Survey, Report on Allegany County, p. 179.

Vein, the Tyson coal is separated by thin slates into three members, the top coal being generally more than 12 inches thick, the middle coal from 3 to 4 feet and the bottom from 1 to 2½ feet." The thickness of good coal varies from 7 feet near Franklin to 4 feet near Lonaconing.

In Ohio the Meigs creek coal, named from a stream in Morgan county, has been identified as the Sewickley vein. Near Bellaire this coal is four feet thick, 80 to 95 feet above the Pittsburg coal, and is called the Upper Barnesville or Upper Bellaire vein, but it is not mined. Professor C. N. Brown[1] states that this is the only coal worked on any scale in eastern Morgan, Noble, southeastern Muskingum, or southern Guernsey counties. It is of good thickness in Belmont, northwestern Monroe, eastern Harrison, and southern Jefferson counties, but is there overshadowed by the underlying Pittsburg. Its structure in Meigs township, Muskingum county, is:

	Ft.	In.
Rotten coal	2	8
Clay	1	8
Coal	1	6
Slate	0	1
Coal	1	4
Slate	0	1
Coal exposed	1	6

In Ohio county, W. Va., the Sewickley coal is separated into two seams as in Maryland. The two coals are 12 feet apart on Chapline hill, Wheeling, and 14 feet at Triadelphia. In this area the Upper Sewickley coal is usually thicker than the Lower. Opposite Carter's run the structure of the Sewickley coals shows:

	Ft.
Upper Sewickley coal	2
Calcareous shales with thin streaks coal	18
Lower Sewickley coal	1

At the Creighton slope mine on Peter's run, east of Elm Grove, a similar structure is seen:

	Ft.	In.
Upper Sewickley slaty coal	2	6
Shales	22	
Lower Sewickley	2	

1. Ohio Geol. Survey, Vol. V, p. 1070.

At Triadelphia, the Lower Sewickley vein is under the water of the creek but is reported as 3 feet thick, the Upper Sewickley as mined at the Knight bank varies from 3 to 4 feet and shows a local increase to 6 feet in a small basin east of Triadelphia.

When the Sewickley coals are traced into Ohio, a similar division into two seams is seen. According to Dr. Stevenson, the Upper coal is of workable thickness in eastern Belmont county but disappears within 20 miles west from the Ohio river. In the section at Bellaire, as measured by Professor Brown, there is a local three fold division:

	Ft.	In.
Coal	4	
Sandy shales	13	10
Coal	0	8
Shale argillaceous	6	0
Coal	3	0

As the Sewickley coal was traced northward in the Ohio-Brooke county area, one of the two seams disappears and the remaining one is only a few inches thick, being represented in some sections by a black slate. This decrease in thickness of the coal agrees with Dr. Stevenson's observations in Pennsylvania. He also states that while the upper vein is of workable thickness in eastern Belmont county, Ohio, it disappears northward along the river long before Steubenville is reached.

The evidence available in the Pan Handle area would indicate that the seam which remains at the north is the Upper Sewickley, and that the Lower has been cut out. In the Elm Grove area there is a band of three inches of coal black slate near the top of the Redstone limestone and the Lower Sewickley coal lies 8 to 10 feet above this shale. In the Fulton section, where there is only one seam of the Sewickley exposed, the black slate was found in the Redstone limestone, and 30 feet higher is the Sewickley coal horizon, represented by black slate, this would represent the proper distance for the upper seam.

Near Wellsburg the Sewickley coal blossom is 3 inches thick and 7 feet lower is a black slate which probably represents the lower vein. The distance from the Pittsburg coal to the Upper Sewickley, where both Sewickley coals are present, is 63 to 88 feet. At the north, where only one Sewickley coal is found, this

interval is 75 to 94 feet, which would correspond to the Upper rather than the lower seam.

The Sewickley coals in the Pan Handle area are usualy too thin for profitable mining. The upper vein was formerly mined a short distance up Peter's run on the Creighton farm, where the coal is one foot and two inches thick with black slate below and a clay and shale roof. It was worked in a number of mines about Triadelphia and was known as the Triadelphia seam, but at the present time it is only worked at the Knight bank at the east edge of town, where the coal is 3 to 4 feet thick, separated from the overlying Benwood limestone by three feet of shales. A small mine has been opened in this vein one mile up Boggs run, east of Benwood. The coal in this mine is about 70 feet above the Pittsburg and is 30 inches thick with 30 inches of roof clay separating it from the overlying limestone. In the river bluffs near Benwood and South Wheeling the Upper Sewickley is 10 inches and 18 feet lower is the Lower Sewickley one foot thick.

South of Beach Bottom, in the southern part of Brooke county, the Sewickley coal is quite slaty, one foot thick, with fourteen inches of black slate above and eight inches of black slate below. Further north it decreases in thickness and is rarely over a few inches, but is generally present in the sections above the Pittsburg coal.

The Sewickley Limestone.

The interval between the Sewickley and Redstone coals, 30 to 60 feet, contains limestone, shales, and thin sandstones. In the Pan Handle area the limestone is well developed, filling most of the space. The limestone was named by Stevenson in Pennsylvania, the Fishpot, from a run in southern Washington county, but later he changed the name to Sewickley limestone. When this limestone is traced southward in West Virginia to the Little Kanawha, and westward in Ohio, it gradually disappears and its place is taken by shales and sandstones.

In Ohio and Brooke counties, West Virginia, the Sewickley limestone varies from 10 to 30 feet in thickness. In the Wheeling area the limestone is well developed, but further north near Wellsburg the interval contains also shales and sandstones. The rock in its typical development is light gray in color, breaking

with smooth and almost shelly fracture. It is hard, but brittle, and is used at a number of places for road material.

Near Benwood and north along the river where the limestone is well exposed in the steep river bluffs, the Redstone coal is often absent or concealed so that the Sewickley and Redstone limestones form nearly a solid mass of rock 50 to 65 feet in thickness.

The composition of the Sewickley limestone near Wheeling is shown by the following analyses which show the rock to be high in silica and magnesia:

	East of Wheeling Opp. Carter's Run.	Benwood near Riverside.
Lime carbonate	74.58	54.97
Magnesium carbonate	10.63	25.08
Silica	9.96	16.40
Alumina	3.28	3.20
Iron oxide	1.54	
Titanium	0.10	

The Redstone Coal.

The Redstone coal was named by H. D. Rogers from Redstone creek in Fayette county, Pa., where it was first recognized. In typical sections, its horizon is 50 to 70 feet below the Sewickley coal and 30 to 50 feet above the Pittsburg. In Pennsylvania this coal is usually thin but reaches 3 to 4 feet in some parts of Fayette and Westmoreland counties. The coal has been mined in Monongalia and Barbour counties, West Virginia, with a thickness of 4 to 6 feet.

The structure of this coal where it is of economic importance is shown at the Century mine in Barbour county.[1]

	Ft.	In.	Ft.	In.
Bone coal	0	4	5	11⅓
Coal	5			
Slate	0	⅓		
Coal	0	7		

In Maryland, according to G. C. Martin, the Redstone coal has a thickness of about 4 feet, and is 18 to 45 feet above the Pittsburg, but so far it has not been mined. In Ohio the coal is known as "8-A," variable in thickness and of no economic importance.

In Ohio and Brooke counties, West Virginia, the Redstone coal blossom is usually present in the sections 30 to 63 feet below the Sewickley coal and 20 to 30 feet above the Pittsburg. Its

1. W. Va. Geol. Survey, Vol. II, p. 161.

thickness averages about six inches, and it appears to be absent in a number of places around Wheeling and in the Creighton slope mine on Peter's run near Elm Grove. When the Redstone coal is present in the Wheeling area the interval to the Pittsburg is 25 to 30 feet; along Short creek, 31 feet. A short interval was measured in the "coal cut" of the B. & O. railroad east of Wheeling. (See plate VII).

	Ft.	In.
Limestone	6	
Shales	1	6
Coal, Redstone	10	10
Limestone, Redstone	12	
Shales	3	
Pittsburg coal.		

The roof of the Redstone coal is usually shale, but in places as on Chapline hill, Wheeling, the Sewickley limestone forms the roof. The greatest thickness of the Redstone coal was found one mile and a half west of Bethany, where it reached 2 feet and 2 inches with 10 feet of shales above, and limestone below. This coal is not mined at any place in the Pan Handle area.

The Redstone Limestone.

Below the Redstone coal is the Redstone limestone, separated from the Pittsburg coal by a few feet of shales. This limestone is present in nearly all the Pan Handle sections, varying in thickness from a few feet to 20.

The Redstone limestone is well exposed on the slopes of Chapline hill and along the Ohio river bluffs south to Benwood. It was quarried at one time for fluxing stone at the Riverside steel plant and a tunnel was driven through the hill to Boggs run on this horizon. It forms the bed of Wheeling creek at Elm Grove and is quarried at the edge of that town for road material. In the Wheeling area the upper portion of the rock is quite shaly, but the lower part is a compact bluish gray rock breaking with a smooth fracture and quite hard.

The chemical composition of the Redstone limestone near Elm Grove and at the tunnel near the Riverside steel plant is shown by the following analyses:

	Elm Grove.	Riverside.
Lime carbonate	76.86	79.42
Magnesium carbonate	5.22	6.81
Silica	11.87	11.60
Alumina	4.68	1.90
Iron oxide	1.97	
Titanium	0.09	

The Pittsburg Sandstone.

When the interval above the Pittsburg coal is studied in different parts of the Appalachian coal basin, it is found to be variable. The conditions in the Fairmont region are thus described by Dr. I. C. White (W. Va. Geol. Survey, Vol. II, p. 163):

"In the Fairmont region and especially along the eastern crop of the Pittsburg coal, there is often found a thick, coarse, gray sandstone, usually very soft, and readily disintegrating when exposed to the weather. When this sandstone is present in a massive condition the overlying Redstone coal and limestone are nearly always absent. * * * * * When massive, the sandstone contains much feldspathic material and easily disintegrates into a bed of coarse sand where exposed along the roads, etc. It has been quarried to some extent for building stone in the Fairmont region, but it furnishes a poor quality which stains badly and will not long endure the action of the elements." This sandstone was named by H. D. Rogers the Pittsburg sandstone.

In the Pan Handle area the interval between the Redstone coal and the Pittsburg usually contains the limestone and shales, but south of Wellsburg, on Green's run, a sandstone is found above the Pittsburg coal, also one and a half miles northeast of Holliday's Cove, a similar sandstone is found at this horizon. Along the northern outcrop of the Pittsburg coal south of King's creek, the interval of 22 feet from the coal to the top of the hill contains fine sand, due in all probability to the weathering of friable sandstone.

The Pittsburg Coal.

The lowest member of the Monongahela series, and the most important stratum in the Carboniferous, from an economic standpoint is the Pittsburg coal, so named in 1856 by J. P. Lesley. This is the important coal seam at Pittsburg, and is the coking coal of Connellsville. It extends eastward into Maryland where it is known as the "Big Vein" or "Fourteen foot" coal, and reaches its greatest thickness, 22 feet, in the southern end of the Georges creek basin.

This coal extends southward in an unbroken sheet up the Monongahela river, and is the principal coal mined in Marion, Harrison and Taylor counties, and is found further south. In Ohio the western outcrop of the Pittsburg coal is found in the

eastern part of Gallia county following a northeast line through Meigs, Guernsey, Harrison, to northern part of Jefferson county. Dr. I. C. White has estimated the area of workable Pittsburg coal remaining in Ohio, West Virginia and Maryland to be about 6,000 square miles.

In the Pan Handle area, the Pittsburg coal underlies the greater part of Ohio and southern Brooke counties. It outcrops along the Ohio river north and south of Wheeling, and up Wheeling creek nearly to Elm Grove, at which place it is mined in a 65-foot shaft. The cover of rocks increases in thickness eastward and southward toward the Pennsylvania line and Marshall county.

Where the coal is found buried under the mass of rocks, its depth can be approximated from the coal outcrop lines marked on the economic maps accompanying this volume. Its horizon is 230 to 270 feet below the Waynesburg coal, 320 to 360 feet below the Washington, 430 to 475 feet below the Dunkard. The deep wells drilled in the area for gas and oil record the presence of this coal with good thickness, 6 to 8 feet. On Middle Wheeling creek at Twilight, the Pittsburg coal was struck at 169 to 250 feet, the difference in depth being due to difference in elevation of the tops of the wells. Up Middle Wheeling creek near the mouth of Gillespie run in the Dodds well, this coal was 296 feet down. South of Dallas on Turkey run, its depth was 586 feet in the Armstrong well. On Coulter run, two miles southeast of Valley Grove, it was found at 435 feet in the McGlumphy well.

North of Wheeling the Pittsburg coal outcrop is seen in the river bluffs 100 feet above the Ohio river at Wheeling, 352 feet above the river at Wellsburg. The coal outcrops on Short creek as far up as Shannon, up Buffalo creek to one mile east of Bethany. The Pittsburg coal forms a continuous body as far north as Cross creek in Brooke county. North of this stream, the coal comes in again as a large island mass with very irregular boundary due to erosion, and extending north nearly to Harmon creek. North of Harmon creek, the coal occurs in two large island masses and a number of outliers disappearing in the hills south of King's creek in Hancock county.

The Pittsburg coal is mined in railroad mines near Wheeling, Elm Grove, Wellsburg, and on Cross creek. The farthest railroad mine to the north is that of the Lewis and Findlay Coal Co.,

one mile west of Colliers near the Pennsylvania railroad. The next large mine at the north is that of the Rex Carbon Coal Co., on the Wabash railroad on Cross creek, five miles south of the Colliers mine. This vein is mined in numerous farmers' banks for a local supply on Glenn's run, north of Wheeling, Boggs run and the river bluffs south of Wheeling, out Middle Wheeling creek near Greggs and Fulton. It is also mined on Short creek, Buffalo, and Cross creek, as well as many of the smaller tributary streams. There are a number of small mines along the extreme northern outliers of this coal south of Kings creek.

The elevation of the Pittsburg coal above sea level in the Pan Handle area has been determined at the following places. These levels were connected with United States Geological Survey bench marks near the coal outcrops, by the use of the hand level or barometer:

South of Osburn's Mills (south of King's creek) Truax mine	1200 A. T.
One mile northeast of Holliday's Cove near church	1153
Southeast of Collier's Station	1140
One mile west of Collier's town	1090
South of New Cumberland Junction	1100
Above Wheeling Junction, Mentor mine	1120
East of Fairy Glen, McKim mine	1065
Forks road east of Ebenezer run	1074
Pennsylvania line south of Wabash R. R	933(?)
East of Wellsburg, Cram mine	993
East of Bowman	951(?)
Hukill run	892
West of Bethany, Beck mine	865
East of Bethany, Bell mine	854
Southeast of Bethany, Barclay mine	827(?)
Glenn's run	816
Greggs, McKinley mine	759
Benwood, Benwood mine	645
Elm Grove shaft coal	629
Peters run, Creighton slope	647

From Wellsburg to Bethany, a distance of four miles and a half, the dip of the Pittsburg coal is 128 feet, or 28.4 feet to the

mile southeast. From Bethany to Glenn's run, a distance of eight miles and a half southwest, the dip is only 49 feet, or 5.7 feet to the mile.

From Glenn's run to Greggs, a distance of two miles and a half, the dip is 57 feet, or 20 feet to the mile almost due south. From Greggs to Elm Grove, three miles and a fourth, the dip is 130 feet, or 40 feet to the mile along a line S. 20° E. From the Lewis mine south of Wellsburg to the Elm Grove shaft mine, a distance of fourteen miles and three-fourths, the dip is 354 feet or 24 feet to the mile along a line little west of south.

The dip of the Pittsburg coal averages in the Pan Handle area about 20 feet to the mile south, and runs 24 to 40 feet southeast through the southern part of Brooke and Ohio counties.

North of Wellsburg the dip of this coal seam is not as regular as south of that place, and there appear to be local depressions in the basin. The dip from the northern outcrop south of King's creek to below New Cumberland Junction, two miles and a quarter southwest, is 100 feet, or 41.6 feet to the mile, which is too large. Southwest to Colliers, four miles and three-fourths, the dip is only 60 feet, or 12.6 feet to the mile.

From Wheeling Junction south to Wellsburg, a distance of seven miles and a half, the dip is 127 feet, or 16.9 feet to the mile, nearly a normal dip. From Wellsburg east to the state line, four miles, the dip is 60 feet, or 15 feet to the mile.

From Wheeling Junction east two miles, the coal dips 30 feet, or 15 feet to the mile, but it then rises 50 feet in two miles at Colliers Station. From Wheeling Junction along a southeast line five miles to the east of Ebenezer run, the coal dips only 46 feet, or 9 feet to the mile, when it should fall 25 to 30 feet to the mile in this direction. If this line, however, is followed eight miles southeast to the state line, the dip is about normal, 23.5 feet to the mile. From the northern outcrop to Wellsburg, 11 miles south, the dip is 207 feet or 18.8 feet to the mile, about normal.

The Pittsburg coal basin north of Wellsburg thus appears to be elevated southeast of Colliers and east of Ebenezer run; while there are marked depressions at the Rex mine on Cross creek, south of New Cumberland Junction (1100 A. T.), and east of Fairy Glen (1065 A. T.) If these levels were corrected for the normal dip they would read about 1155 below New Cumberland Junction, and 1100 east of Fairy Glen, which would in-

dicate that the depression south of the former was 55 feet, and the latter 35 feet.

THICKNESS AND QUANTITY OF THE PITTSBURG COAL IN THE PAN HANDLE AREA.

The thickness of the roof coal in the Wheeling area varies between a foot and a half and one foot, and is separated from the main bench by one to two feet of fire clay. In the Brooke county areas the roof coal is only a few inches thick and the clay between it and the main bench is eight inches to one foot.

The thickness of the main bench of the Pittsburg coal near its northern boundary is 4 feet to 4 feet 8 inches, with a local increase at the Rex mine, south of the Wabash railroad, to nearly 6 feet. This mine shows great variation in thickness in the different workings, and would probably average with the other mines. A similar local increase in thickness occurs at the Cram mine east of Wellsburg, where the coal reaches 5 feet 9 inches. Three miles southeast of Wellsburg the coal is 6 feet 10 inches thick in the Carmichael mine, but further east near Bethany it averages about 5 feet.

Along Short creek in Ohio county the Pittsburg coal is 4 to 5 feet 4 inches. In the vicinity of Elm Grove it is 5 feet 6 inches to 5 feet 9 inches, reaching 6 feet 10 inches in some of the Wheeling mines. Deep well records report the Pittsburg coal as 8 to 10 feet, but this measurement includes the roof coal and slate.

The average thickness of the Pittsburg coal in Brooke county may be taken as 4 feet 6 inches; and in Ohio county it is probably 5 feet 6 inches. While the Pittsburg coal lies hidden through most of the area of Ohio county, the various wells drilled over the county for gas and oil show that it is persistent and with good thickness.

The area underlaid by the Pittsburg coal in Ohio county is 66,944 acres, and assuming an average thickness of 5 feet, which represents a conservative estimate, the total tonnage would be 585,760,000. The area of Marshall county included with the Ohio county map accompanying this report is 12,147 acres, with 106,286,240 tons of Pittsburg coal.

The area underlaid by the Pittsburg coal in Brooke county is:

South of the Wabash railroad	27,930	acres
Between the Wabash and Penna. railroads	7,572	"
North of the Pennsylvania railroad (including also Hancock county)	1,500	"
Total	37,002	"

This area of coal with a thickness of 4 feet 6 inches, would yield 290,586,160 tons.

The total tonnage of Pittsburg coal in the northern Pan Handle area would be:

Portion of Marshall county	106,286,240
Ohio county	585,760,000
Brooke and Hancock counties	290,586,160
Total	982,632,400

The coal in these counties has been mined along the river at a few places, and on a small scale up the various creeks back from the river; but the total amount of coal thus removed is very small compared with the total tonnage as computed above.

STRUCTURE OF THE PITTSBURG COAL.

The division of the Pittsburg coal into two parts, and the very constant arrangement of the slate partings are so characteristic that the coal can always be identified by its structure. The first detailed study of the coal was made in Pennsylvania by Dr. J. J. Stevenson, who described in detail the structure of the seam,[1] and the divisions have been named as follows:

Roof coals.
Over-clay.
Breast coal.
Parting.
Bearing-in coal.
Parting.
Brick coal.
Parting.
Bottom coal.

1. 2nd Geol. Survey of Penna. Report K, p. 70; 1875.

The *roof coal* varies in thickness from two inches to eight feet and may be a single bed, though it is often divided by slates into several small veins. Dr. Stevenson mentions one locality where there are twenty divisions. The coal is usually high in ash and is seldom used. In the Wheeling area this division is one to two feet thick, but along the northern outcrop in the Pan Handle it is only two to four inches.

The *over-clay* is an impure gray to black fire clay, much slicken-sided and liable to cave, so it is usually removed for safety, leaving the roof coal for the roof of the mine. In the Pan Handle area it varies in thickness from a few inches to two feet.

The *breast coal* or main bench is usually the thickest division, reaching three to six feet on the Monongahela, and one to three feet in the Pan Handle area. The top layer of the main bench is apt to be harder and of a bony nature, sometimes containing pyrite nodules.

The *bearing-in coal* was so named by the miners because the main bench is usually under-cut in this layer. It runs two to eight inches in thickness in this area and is included between the twin slates or partings which are one-eighth to one-half inch in thickness.

The *brick coal* under the lower of the twin slates is usually about one foot thick along the Monongahela river, and the coal comes out in oblong, rectangular blocks resembling bricks in shape, hence the name. The parting between the brick and bottom coal, according to Dr. I. C. White, is always present along the Monongahela from Brownsville to Pittsburg, but it is rarely present in the Fairmont region.

In the Pan Handle area there is sometimes present a soft streak called the "soot" seam separating the brick coal from the lower coal, but in many mines it is so indistinct as to be overlooked and the entire thickness below the lower twin slate is then called the bottom coal.

The *bottom coal* is 12 to 20 inches thick along the Monongahela in Pennsylvania, and there contains such numerous thin slaty sulphur layers that it is often left in the mine. In the Fairmont and Cumberland regions this coal is mined with the rest of the seam. Where the roof and bottom coals are left in the mines as in Pennsylvania, Dr. I. C. White has estimated the waste as 3000

tons per acre. In the Pan Handle area the bottom coal is mined with the brick division. Its thickness runs eight inches to one foot, or including the brick coal, one and a half to three feet.

The structure as described above is so characteristic over a large area that it is recognized by all who have worked in this seam, miner, engineer, or geologist, as a certain test for the Pittsburg coal. Dr. I. C. White, who has made a detailed study of this coal through the four states where it is found, says in the West Virginia coal report (Vol. II, p. 171):

"This type of structure is practically universal over all of the Pennsylvania, Maryland, and eastern Ohio area of the bed. The different members vary considerably in thickness, as for instance the gradual increase of the "breast" coal from three feet at Pittsburg to six feet at Brownsville, 58 miles up the Monongahela river, or to seven and even ten feet in the Georges creek and North Potomac regions of Maryland and West Virginia, or a decrease may take place in the same to thirty and sometimes to twenty inches, as in the Wheeling and Bellaire regions, but each of the main sub-divisions can be distinctly recognized, so that whether at Fairfax Kob, on the summit of the Allegheny mountains, 3200 feet above the level of the sea, or deep down in the center of the great Appalachian trough buried under 1500 feet of sediments, the explorer can readily identify this great coal bed, not only from its associated rocks, but from its stratigraphical elements as well, and from even the fracture of the coal."

This structure may be illustrated by a section of the Opekiska mine, 10 miles below Fairmont:[1]

		Ft.	In.	Ft.	In.
Roof coal				0	11
Black slate				0	5
Breast coal	Coal	1	8	3	4½
	Bone	0	½		
	Coal	1	8		
Bands	Bone	0	¾	0	6½
	Coal	0	5		
	Bone	0	¾		
Bottom coal				4	1

The structure of this coal (Big Vein) in Maryland is given in the following section below Lonaconing:[2]

1. W. Va. Geol. Survey, Vol. II, p. 174.
2. Md. Geol. Survey, Report, Allegany County, p. 177.

			Ft.	In.	Ft.	In.
Roof coal			2	8		
Bony coal			0	8		
Breast Coal			8			
Slate			0	1		
Coal	0	4				
Slate	0	1			10	4¼
Coal	1	0	2	3¼		
Slate	0	¼				
Coal	0	10				

In Jefferson county, Ohio, the structure is as follows:[1]

	Ft.	In.	Ft.	In.
Roof coal	2	3	2	7
Clay	0	4		
Coal, breast	2	2		
Clay parting	0	2		
Coal	0	2		
Black slate	0	⅓	4	11⅓
Coal, brick	1	3		
Parting	0	..		
Coal, bottom	1	2		

A typical section, illustrating the Pittsburg coal structure in the Pan Handle area, is taken from the Creighton slope mine east of Elm Grove.

	Ft.	In.	Ft.	In.
Roof coal	1	8		
Over-clay	2			
Breast coal	2	9		
Parting	0	⅛		
Bearing-in coal	0	3		
Parting	0	⅛	5	4½
Brick coal	1	8		
Soot seam	0	¼		
Bottom coal	0	8		

Two sections are also given to show the structure in the northern portion of the Pittsburg coal area of the Pan Handle.

	Rex mine.		Campbell mine.	
	Ft.	In.	Ft.	In.
Roof coal	0	10	0	2
Over clay	0	10	1	
Breast coal	2	8	2	
Parting	0	¼	0	¼
Bearing in coal	0	3	0	2½
Parting	0	¼	0	¼
Bottom coal	0	10	2	0
Coal	4	9½	4	3

The chemical composition of the Pittsburg coal in the Pan Handle area is discussed in the chapter on economic resources.

1. Ohio Geol. Survey, Vol. VI, p. 603.

CHAPTER V.

THE CONEMAUGH SERIES.

This series was formerly known as the Lower Barren Measures, and later as the Elk River Series, but the earlier name of Conemaugh, given by Franklin Platt in 1875, from the typical development along the Conemaugh river in western Pennsylvania, is now generally accepted.

The Conemaugh Series as now limited includes the rock strata from the bottom of the Pittsburg coal down to the top of the Upper Freeport seam. The thickness of the series varies from 300 feet along the western outcrop in Ohio to 450 feet in the Pan Handle of West Virginia, to 800 feet near Charleston. The rocks show considerable contrast in the upper and lower portions of the series. The upper part includes buff and red shales with limestone layers, while the lower is characterized by coarse and massive sandstones.

The contrast in character causes a marked change in topography as described by Dr. I. C. White.[1] "The uppermost 400 feet of soft beds with their included thin limestones and limy, red, yellow, and greenish shales, interstratified with two to three rather massive sandstones, gives origin to a beautiful, rolling topography often finely adapted to grazing and agriculture, especially where these beds cover the uplands not deeply trenched by draining streams. When the hills are high and steep, however, the red marly shales exhibit a great tendency to landslides, and hence where such topography abounds, grazing rather than agriculture should be the chief occupation for these Conemaugh soils."

"In strong contrast with these soft, yielding, unstable beds, which make the upper two-thirds of the Conemaugh series, may be placed the massive, gray, pebbly sandstones, which form its basal members. These rocks are quite hard, and the sand grains being cemented with peroxide of iron, or silica, resist erosion and form a protecting roof to the underlying Allegheny-Kanawha coal

1. W. Va. Geol. Survey, Vol. II, pp. 227, 230.

series, long after the soft red beds above have disappeared. Along all the larger streams they crop in bold, precipitous cliffs, and on the smaller tributaries form narrow gorges, water falls, and rugged scenery generally. As a topographic element in the landscape, they can be followed with the greatest ease from knob to knob, and hill to hill."

The character and order of the rock formations in the Conemaugh Series are shown in the following typical section of Dr. I. C. White in Allegheny county, Pa.[1]

General Section of the Conemaugh Series in Allegheny Co., Pa.

	Ft.
Pittsburg Coal.	
Concealed	20
Upper Pittsburg limestone	2
Variegated shales	65
Little Pittsburg coal (wanting)	0
Lower Pittsburg limestone	5
Red shales	20
Concealed	70
Morgantown sandstone	45
Variegated shales	50
Elk Lick coal	0 to 3
Elk Lick limestone	0 to 5
Variegated shales	35
Ames Limestone	2 to 3
Harlem coal	0 to 1½
Red shales, Pittsburg	30
Sandy shales and shaly sandstone	50
Bakerstown (Barton) coal	0 to 4
Shales and sandstone	40
Cambridge (Pine Creek) limestone	2
Buffalo sandstone	60
Brush Creek limestone	1 to 2
Dark shales	10 to 15
Brush Creek coal	0 to 3
Shales	20
Mahoning sandstone	40 to 80
	570 to 630

Mean height of section, 600 feet.

A typical section of the Conemaugh Series in West Virginia was measured by Dr. I. C. White at Morgantown, and is given as follows in the Survey coal report (Vol. II, p. 230):

1. 2nd Geol. Survey Penn. Report Q, p. 24; 1876.

Section at Morgantown, Monongalia County, W. Va.

Pittsburg Coal.	Ft.	In.	Ft.	In.
Fire clay	2			
Sandy shales and sandstone	32			
Coal, Little Pittsburg	1	6		
Sandy shales	17			
Limestone	1			
Yellowish shales with iron ore	10			
Sandy shales and concealed	17			
Sandstone, rather massive	25			
Sandy shales and concealed	15		285	6
Massive sandstone, Connellsville	20			
Bluish green sandy beds	20			
Black slate, fossiliferous	1			
Limestone, Clarksburg	1			
Shales and sandy beds	45			
Sandstone, Morgantown	20			
Coal, Elk Lick	3			
Shales and concealed	55			
Limestone, crinoidal, Ames	1	6		
Variegated shales	85	6		
Limestone, Upper Cambridge	1			
Shales	14			
Sandstone, Buffalo	3	6	275	6
Shales and shaly sandstone	30			
Massive sandstone, Upper and Lower Mahoning	100			
Shales	40			
			561	0

The following general section of the Conemaugh Series in Hancock county of the Pan Handle area has been made by combining the various partial sections in that county and may be taken as a typical section of this series in this area, though the total thickness of the series is greater than measured at any one place.

General Section of Conemaugh Series in Hancock Co., W. Va.

	Ft.	in.	Ft.	in
Pittsburg coal.				
Shales	10			
Limestone, Upper Pittsburg	3			
Shales, sandstone and concealed	35			
Limestone, Lower Pittsburg	2			
Shales, sandstone and concealed, Connellsville sandstone horizon	48		225	6
Limestone, Clarksburg	2			
Shales and concealed	70			
Sandstone, Morgantown	25			
Coal Elk Lick	0	6		
Shales	30			
Limestone, fossiliferous, Ames	10			
Coal, Harlem	0	6		
Shales, Pittsburg Red Shales	50		120	6
Sandstone, Saltzburg	30			
Shales and concealed	30			

Limestone, fossiliferous, Cambridge	4	44
Shales and concealed	40	
Limestone, Brush creek	2	91
Coal, Brush creek	1	
Sandstone and shales	60	
Coal, Mahoning	3	
Shales and concealed	25	
Upper Freeport coal.		
		481

The coals of this series are usually thin and less valuable than those of the Monongahela Series. The most important coals in this area are the Mahoning, near New Cumberland, the Brush Creek (Mason) and Barton (Bakerstown) in the northern part of Hancock county. With the execption of the Mahoning, none of these coals is worked in railroad mines, though the Barton coal, known locally as the Blanche vein, was worked near Colliers on the Pennsylvania railroad, but these mines are now abandoned.

There are a number of small limestone ledges through the series, of which the most important are the Ames, Cambridge, and Brush Creek, varying in thickness from 2 to 15 feet. These three limestones are of little economic importance, but form valuable guides in the identification of the strata, and afford important clues to the position of the Pittsburg, Freeport, and other coal seams.

The Conemaugh Series is exposed through the northern portion of the Pan Handle area, but outside of the Kings creek area it is impossible to secure complete sections, since the Pittsburg coal only extends north to the hills south of this creek, and the Upper Freeport coal does not outcrop south of this stream. The Kings creek section at Osburn's Mill is given in the introductory portion of Part II of this report and shows a total thickness of 465 feet for the Conemaugh Series in this area.

A section of the Conemaugh was made at Wellsburg, Brooke county, by combining the hill section with the record of the old coal shaft sunk to the Roger or Lower Freeport coal in the Allegheny series. This shaft record has been furnished by Mr. J. C. Cram, who was superintendent of the mine, and one of the old coal operators of this county.

Plate VI.—Sewickley Limestone on Little Wheeling Creek Near Elm Grove, Ohio County.

Section at Wellsburg, Brooke County.

	Ft.	in.	Ft.	in.
Pittsburg coal.				
Concealed	16			
Coal blossom, Little Pittsburg	0	2		
Sandstone	2			
Shales and concealed	32	7		
Limestone, blue	2			
Shales	30	7	230	
Limestone, gray, nodular	2			
Shales, buff	25	10		
Limestone, gray, Clarksburg	2			
Shales and concealed	32	6		
Sandstone, Morgantown	12	4		
Shales and concealed	72			
Limestone, Ames	5			
Shales	20			
Coal blossom	0	6		
Shales and concealed	43			
Shaly sandstone and shales	12			
Sandstone	15			
Continued from Coal shaft record				
Shales	25		227	6
Plastic clay	20			
Sandstone	42			
Clays	10			
Limestone, hard	3			
Slate	18			
Fire clay	6			
Slate and clay	8			
Coal, Upper Freeport	1	6		
To Lower Freeport coal	75			
			457	6

This section would give 457 feet as the thickness of the Conemaugh Series at Wellsburg. Further south in the Central Glass Co. well, at Wheeling, the record would give a thickness of 500 feet for the Conemaugh.

Partial sections of the Conemaugh Series are exposed at many places in Hancock and Brooke counties. The following section at Colliers extends from the Pittsburg coal to the Saltzburg sandstone:

Section at Colliers, Brooke County.

	Ft.	in.	Ft	in.
Pittsburg coal.				
Shales and concealed	22			
Sandstone	1			
Shales, buff	10			
Concealed	30			
Limestone, Pittsburg	2			
Shales	20		220	6
Concealed	45			
Sandstone, Morgantown	25			
Shales, buff	20			
Black slate and blossom, Elk Lick	0	6		
Limestone, nodular	0			
Shales and concealed	45			
Limestone fossil, Ames	12			
Coal blossom, Harlem	0			
Shales and concealed	18		112	6
Sandstone	2	6		
Shales, sandy and concealed	40			
Sandstone shaly, Saltzburg	40			

The following section was measured on the North Fork of Kings creek near the Pennsylvania line, and reaches from below the Ames limestone, nearly to the Pittsburg coal, but the highest hills in this area are too low for this seam.

Section on North Fork, Kings Creek, Hancock County.

	Ft.	in.	Ft.	in.
Limestone gray, Upper Pittsburg	3			
Shales and concealed	15			
Shaly sandstone	10			
Shales	10			
Shaly sandstone	2			
Coal blossom, Little Pittsburg	0			
Limestone, brecciated, Lower Pittsburg	5			
Connellsville { Shaly sandstone	12			
Connellsville { Sandstone, solid	10			
Shales	5		224	
Limestone, gray	1			
Shales	50			
Limestone, irregular, Clarksburg	5			
Shaly sandstone, Morgantown	53			
Limestone blocks, Elk Lick	2			
Shales	18			
Sandstone	4			
Shaly sandstone	10			
Shales	9			
Limestone, fossiliferous, Ames	5			
Coal blossom, Harlem	0	2		
Shales	18			
Red clay	3			
Shales	50		136	2
Shaly and flag sandstone	27			
Sandstone	18			
Shales	15			
			360	2

Another section was measured to the south from the top horizon of the above section, following Lick run, with part of the concealed intervals restored from sections to the south of Kings creek, and down this stream. This section is taken along the direction of southern dip of the strata.

Section on Lick Run, Hancock County.

	Ft.	in.	Ft.	in.
Shales	9			
Limestone, Upper Pittsburg	3			
Shales with sandstone layers	20			
Sandstone, flag	3			
Shales, buff	15			
Limestone, Lower Pittsburg	2+			
Concealed	15		225	
Shales and sandstone	36			
Limestone, nodular	0			
Shales, buff	12			
Limestone, nodular, Clarksburg	3			
Shales, sandstone, and concealed, Morgantown	50			
Concealed	38			
Shales, Birmingham	20			
Limestone, fossiliferous, Ames	8			
Pittsburg Red Shales: Shales	36			
Pittsburg Red Shales: Sandstone	8			
Pittsburg Red Shales: Shales	41			
Sandstone, shaly	4			
Shales	28			
Limestone, fossiliferous, Upper Cambridge	1		213	6
Shales and sandstone layers	30			
Coal blossom and black slate, Brush creek	0	6		
Shales	9			
Sandstone, Mahoning	30			
Flag sandstone and shales to Upper Freeport horizon	18			
			438	6

On Mercer run the section from the Ames limestone to the Mahoning sandstone is exposed. The Brush creek coal (Mason) in this area, is worked in a number of small mines. This section, taken nearly a mile along the dip of the beds, would represent too large an interval.

Section on Mercer Run, Hancock County.

	Ft.	in.	Ft.	in..
Ames fossiliferous limestone	2+			
Red shales, Pittsburg	40			
Shaly sandstone	6		195	
Shales and concealed	65			
Shaly sandstone	2			
Shales and concealed	80			

Coal, Brush creek (mined)	2	6		
Shales and shaly sandstone, limestone	54			
Limestone, nodular	2			
Shales	8		95	
Coal blossom, Mahoning	0	6		
Shales and concealed	18			
Sandstone, Mahoning	10			
			290	

The following section was measured at Wheeling Junction and shows a normal interval between the Ames and Pittsburg coal horizons. This section would give the approximate thickness of the Conemaugh series as 440 feet 10 inches.

Section at Wheeling Junction, Brooke County.

	Ft.	in.	Ft.	in.
Pittsburg coal.				
Shales	11			
Limestone blocks, Upper Pittsburg	2			
Shales	9		220	
Sandstone	3			
Shales	54			
Sandstone and concealed, Morgantown	99			
Shales	42			
Red earth—**Ames horizon**	3			
Limestone, nodular	2			
Shales, fine	34			
Sandstone and concealed	18		134	
Shales	22			
Sandstone, partly concealed	43			
Shales	12			
Coal, slaty	1			
Coal, Bakerstown	0	10		
Shales	15		86	10
Concealed to Ohio river	30			
Estimated interval to Upper Freeport coal horizon	40			
			440	10

A section measured with hand level at Fairy Glen, one mile south of the last, shows a decreased interval between the Ames and Pittsburg coal, but as stated under the discussion of the Pittsburg coal in this area, there appears to be a local depression of 35 feet east of Fairy Glen. The present section gives further proof of this view, as the Ames-Pittsburg interval is about 35 feet too short for the average in the Northern Pan Handle. This section indicates the thickness of the Conemaugh at this place to be 434½ feet.

Section at Fairy Glen, Brooke County.

	Ft.	in.	Ft.	in.
Pittsburg coal, (1068 A. T.)				
Shales and concealed	13			
Sandstone, shaly	2			
Shales and concealed	29			
Limestone, Pittsburg	2		188	6
Shales and concealed	28	10		
Concealed	41	4		
Sandstone and sand, Morgantown	25	8		
Shales and concealed	46	8		
Limestone fossiliferous, Ames	5			
Shales, red and brown, Pittsburg Red shales	98	4	147	2
Sandstone	0	10		
Shales	43			
Limestone, nodular and solid, Brush creek	5			
Black slaty clay, Brush creek coal horizon	0	5		
Shales	5		38	10
Sandstone, Mahoning	10			
Concealed to Penn. R. R. track (694 A. T.)	18	5		
Estimated interval to Upper Freeport coal	60		60	
			434	6

The section as measured out the Bethany pike three miles southeast of Wellsburg at the road tunnel, shows the interval between Ames limestone and the Pittsburg coal, and also the red shales cut out in part by the Saltzburg sandstone.

Bethany Pike Tunnel Section, Brooke County.

	Ft.	in.	Ft.	in.
Pittsburg coal.				
Shales	4			
Sandstone, shaly	5			
Limestone, Pittsburg	1	2		
Concealed	10			
Coal blossom	0	2		
Sandstone	1		212	4
Buff shales and concealed	36			
Red earth and fine shales	27			
Limestone, brown, Clarksburg	2			
Sandy shales and concealed	70			
Sandstone, Morgantown	25			
Coal, Elk Lick	1			
Shales, Birmingham	30			
Limestone, fossiliferous, Ames	4			
Shales	27			
Sandstone, Saltzburg	10+			

The above section shows the Ames-Pittsburg interval below the average, but it extends three-fourths of a mile almost north from the coal exposures, so that in a vertical section this interval would probably be increased 15 to 20 feet.

The lower portion of the Conemaugh Series is exposed near New Cumberland in Hancock county, but the Upper Freeport coal is poorly developed or wanting, so that it is not always possible to definitely locate the lower limit of the series.

The following section was made on the hills back of New Cumberland, with the interval below the Mahoning coal taken from the Dornan farm, one mile northeast of town. The Upper Freeport coal horizon is taken as the top of the limestone above 15 feet of flint fire clay, the Bolivar. This horizon is 63 feet above the Roger or Lower Freeport vein on this farm.

Section at New Cumberland, Hancock County.

	Ft.	in.	Ft.	in.
Ames limestone	5			
Shales, Pittsburg Red shale	15		120	
Sandstone, shaly, and concealed	50			
Shales, buff	50			
Limestone fossiliferous, Upper Cambridge	4			
Shales, red	10	9		
Shales, fine	15			
Sandstone ,shaly	13		145	
Shales, buff	49	7		
Shales black, Brush creek coal horizon (?)	2			
Shales and sandstone	50	8		
Coal, Mahoning	3			
Shales and concealed	20		23	
Upper Freeport coal horizon.				
			288	

Section Below Zalia, Hancock County.

	Ft.	in.	Ft.	in.
Sandstone	14			
Shales	27		41	8
Coal blossom, Brush creek	0	8		
Shales	36		63	
Shales and sandstone	27			
Coal (mined), Mahoning	3	4		
Shales and concealed	26		29	4
Upper Freeport coal horizon.				
			134	

The Upper Freeport coal horizon was placed above the limestone which is over 20 feet of Bolivar flint fire clay and is 62 feet above the Lower Freeport coal mined below.

DESCRIPTION OF FORMATIONS.

The Conemaugh Series includes the following formations, with a total thickness of 400 to 500 feet in the Pan Handle area:

Lower Pittsburg Sandstone.
Pittsburg Limestones.
Little Pittsburg Coals.
Connellsville Sandstone.
Little Clarksburg Coal.
Clarksburg Limestone.
Morgantown Sandstone.
Elk Lick Coal.
Elk Lick Limestone.
Birmingham Shale.
Ames (Crinoidal) Limestone.
Harlem (Crinoidal) Coal.
Pittsburg Red Shale.
Saltzburg Sandstone.
Bakerstown (Barton) Coal.
Cambridge Limestone.
Buffalo Sandstone.
Brush Creek Limestone.
Brush Creek (Mason) Coal.
Upper Mahoning Sandstone.
Mahoning Coal.
Lower Mahoning Sandstone.

The Lower Pittsburg Sandstone.

The rock strata for 80 to 100 feet below the Pittsburg coal horizon vary in character in different parts of the Pan Handle area. Near Wheeling and Wellsburg a sandstone 20 to 30 feet in thickness occurs a few feet below the coal. This rock was named by the Pennsylvania Survey the Lower Pittsburg Sandstone. In many places in this area the sandstone is replaced by sandy shales.

In the normal succession of the rocks, every large coal seam should be underlaid by a clay, popularly termed fire clay. No clay was found under the Pittsburg coal in the Pan Handle area, and Dr. I. C. White states (Vol. II, p. 245), "This absence of underclays from the coal beds is quite general in all the upper two-thirds of the Conemaugh series, and it is also universal in the Mononga-

hela series above, since at no locality in the Appalachian field has any fire clay deposit been noted in the latter series of rocks. The highest known fire clay deposit of any economic value is one at the horizon of the Mahoning coal, near the base of the Conemaugh."

The Pittsburg Limestones.

The Pittsburg limestone was named by H. D. Rogers, but since it usually consists of two beds, 40 to 60 feet apart, they were designated by Dr. I. C. White as Upper and Lower.

The Upper Pittsburg limestone is sometimes found close under the Pittsburg coal, but in typical sections is 20 to 35 feet lower. In this area it is a blue to gray rock, one to four feet thick, and often brecciated.

The Lower Pittsburg limestone is 30 to 40 feet lower, and similar in appearance to the Upper. No fossils were found in either stratum. In many of the sections only one limestone was found in this interval, the other being absent or concealed by rock debris. According to Dr. White, the lower limestone is the more persistent and has been quarried and burned for lime in some parts of Pennsylvania. These limestones were found in the sections near Fairy Glen, Wheeling Junction, Hukill run, Wilson, Short Creek, Wheeling, and other places in the area.

The chemical composition of the lower limestone near Morgantown is shown by the following analysis:

Lime carbonate	86.84	per cent.
Magnesium carbonate	2.01	" "
Silica	6.92	" "
Alumina	1.93	" "
Iron oxide	2.31	" "
Titanium	trace	

The Little Pittsburg Coals.

In the interval below the Pittsburg coal, one or two thin coals appear in many of the sections, but are of no economic importance in this area. They were named by the Pennsylvania Survey the Little Pittsburg Coals. The upper one occurs *under* the Upper Pittsburg limestone; and the lower, *over* the Lower Pittsburg limestone. In Somerset county, Pa., the upper coal is 3 to 4 feet thick and the lower one is 18 inches, but over most of the area where these coals are exposed they are thin seams.

In the Pan Handle area the thin blossom of these coals is generally hidden by the overlying shales. In the vicinity of Wellsburg, the upper vein shows as a thin blossom, 16 feet below the Pittsburg coal. Near Short creek one of the seams is 40 to 45 feet below the Pittsburg; and 30 feet below near Holliday's Cove.

The Connellsville Sandstone.

About 60 to 95 feet below the Pittsburg coal and below the Lower Pittsburg limestone, a heavy sandstone is usually found. This stratum was named the Connellsville Sandstone by Dr. J. J. Stevenson, from its typical development at that city.

According to Dr. I. C. White, this rock is one of the finest building stones in the Coal Measures (Vol. II, p. 247): "The sand grains, being cemented by silica and peroxide of iron, are almost weather proof, so that for all structures like bridge piers, outside walls, etc., it has no superior. The iron in the rock often permeates the entire mass so thoroughly as to give it a uniform reddish tint, and again it may have a speckled type, much resembling gray granite."

In its typical development this rock varies from 20 to 50 feet in thickness. In the Pan Handle area the solid sandstone when present at this horizon is only 8 to 15 feet thick, and more often it is replaced by sandy shales with thin shaly sandstone layers.

The Clarksburg Coal and Limestone.

Under the Connellsville sandstone in typical sections, there is a small coal seam, usually thin and slaty, which Dr. I. C. White named the Clarksburg Coal from its outcrop near that city. The bed is often double the two portions separated by a few feet of shale or slate, and the coal is of little or no economic importance. In western Maryland the coal is known as the "Dirty Nine Foot" on account of its slate impurities. When absent, the coal is often replaced, according to Dr. White, by a few inches of black slate generally filled with the teeth, scales and bones of fossil fishes. This coal occurs in a few of the Pan Handle sections as a thin blossom, but even this is usually concealed.

Just under the Clarksburg coal is the Clarksburg limestone, which near Clarksburg reaches a thickness of 20 to 30 feet. It is a very impure limestone, high in magnesia, silica, and alumina. Near Wellsburg in the Pan Handle area this limestone is two feet

in thickness, and is exposed out the Bethany pike as a brown, impure rock. On North Fork of Kings creek near the Pennsylvania line, the Clarksburg limestone is five feet thick and weathers into nodular masses.

The Morgantown Sandstone.

The Morgantown sandstone, so named by Dr. J. J. Stevenson from its fine exposures near that city, is one of the well marked sandstones of this series. It is found, according to Dr. I. C. White (Vol. II, p. 250), "Through Monongalia, Marion, Tyler, Preston, Barbour, Upshur, Lewis, Braxton, Clay, Kanawha, Putnam, Mason, Cabell, and Wayne counties. It is well exposed along the Ohio river in the region of Huntington, where it makes cliffs fifty to sixty feet high along the hills back from the river valley. It is also conspicuous in cliffs along the Guyandotte, Mud, and Coal rivers, as well as along the Great Kanawha, where it has been frequently quarried and used in building the locks below Charleston." This sandstone is thus seen to have a wide distribution in the state and preserves its massive character.

In the northern Pan Handle area, in Brooke and Hancock counties, the Morgantown sandstone is a well marked stratum with an average thickness of 20 to 30 feet. It is a coarse grained sandstone of bluish gray color on fresh fracture, but weathers to a yellow or buff color. It is exposed near Wheeling Junction, Middle Ferry, Wellsburg, Colliers, Short Creek, Wilson, and further north on North Fork Kings creek, and Lick run.

The Elk Lick Coal and Limestone.

The Elk Lick coal occurs in the series just under the Morgantown sandstone. It was so named in Pennsylvania by J. P. Lesley from Elk Lick creek, near Meyersdale, Somerset county, where it reaches a thickness of four feet. This coal has been mined on a small scale near Morgantown, also in Preston county, and further south in West Virginia. In Ohio and in Maryland it is represented by a thin coal or black slate.

In the northern Pan Handle area the Elk Lick coal is usually represented by a thin blossom. Near Colliers it is represented by a poor blossom and black slate with lime nodules below. The best exposure is over the first tunnel on the Bethany pike southeast of

Wellsburg, where the coal is one foot thick just under the Morgantown sandstone.

The Elk Lick limestone underlies the coal, and in parts of Pennsylvania and West Virginia reaches a thickness of 10 to 15 feet. According to Dr. I. C. White (Vol. II, p. 254), "The limestone is of fresh or brackish water origin like all of those in the series above it, but some of the layers are fairly pure and burn into a good quality of lime for building or fertilizing purposes. * * * * It is usually gray in color and resembles the Clarksburg limestone, sixty to eighty feet higher, so closely in physical aspect, that it has probably been frequently confused with the latter." This limestone near Morgantown has the following chemical composition:

Lime carbonate	66.74	per cent.
Magnesium carbonate	7.13	" "
Silica	16.08	" "
Alumina	6.56	" "
Iron oxide	3.41	" "

The Elk Lick limestone in the Pan Handle appears to be absent or concealed in most of the sections. It does not show in the excellent rock exposures above the tunnel on the Bethany pike where the coal occurs. In the eastern part of Hancock county it is seen 40 feet above the Ames limestone, and two feet thick. It occurs in nodular form below the coal near Colliers.

The Birmingham Shale.

The shales above the Ames limestone and below the Elk Lick horizon were named by Dr. J. J. Stevenson, the Birmingham Shales from their exposure at that suburb of Pittsburg. These shales, 20 to 40 feet thick, are found throughout the northern portion of the Pan Handle area just above the Ames limestone. They are usually quite sandy, buff in color, and in the eastern part of Hancock county appear to be replaced in part by sandstone strata.

Near Richmond, on Mills creek, west of Steubenville, Ohio, these shales yielded a fauna of fossil cockroaches, discovered by Mr. Samuel Huston, and described by Professor S. H. Scudder in Bulletin No. 124, U. S. Geological Survey. The types described agree closely with Permian forms found in Europe. This fact with other observations has led Dr. I. C. White to suggest the possibility of the main portion of the Conemaugh being of Permo-

Carboniferous age. The Richmond locality yielded 22 species belonging to three genera, and 17 of the species belonged to one genus, *Etoblattina.*

The Ames or Crinoidal Limestone.

Dr. I. C. White has called attention to the fact that the limestones above the present horizon represent fresh or brackish water deposits, while now in the Ames limestone, marine fossils abound. This limestone has been recognized from an early day as one of the most important guides to the stratigraphy of the coal measures in the Appalachian field. It was named by the first Geological Survey of Pennsylvania the "Green Fossiliferous" limestone, and by Dr. Stevenson in the work of the Second Survey, the Crinoidal limestone, while in Ohio is was named the Ames by E. B. Andrews.

The horizon of this limestone is 200 to 250 feet below the Pittsburg coal, and 200 to 300 feet above the base of the series. The average interval between the Ames and Pittsburg horizons in the Pan Handle area is 225 feet, and from Ames to Upper Freeport coal or the base of the Conemaugh, 245 to 250 feet.

This Ames limestone is usually thin, 2 to 5 feet, but in Brooke and Hancock counties reaches 10 and 12 feet. Its color is blue to gray, but near Wheeling Junction and at many places in Ohio, it is a reddish, granular, and brittle rock, weathering into shaly plates which show a tendency to crumble. Near Osburn's mill the limestone is eight feet thick, with the lower three to four feet shaly and grading into limy shales. This limestone can be followed from below Short creek north to the high hills south of Chester. It forms projecting ledges and water falls in the various creeks, and is exposed in a stratum 10 feet thick in the cut of the Wabash railroad just east of the river. It is exposed in the various roads on the hills north and east of Wellsburg. The outcrop of the Ames limestone is marked by a dotted line on the economic geological maps of Brooke and Hancock counties.

In its geological distribution the Ames limestone extends from Allegheny and Beaver counties, Pennsylvania, southward into Barbour county, West Virginia, and is probably represented by the two-mile limestone near Charleston, according to Dr. I. C. White. Dr. Stevenson states that it may be the fourth fossiliferous limestone of Kentucky, while Dr. Martin identified the

horizon in Garrett county, Maryland. It is also prominent throughout southeastern Ohio.

The Ames is one of the very rich fossil horizons of the Conemaugh. The fossils from this limestone near Morgantown were collected by Dr. J. J. Stevenson (1868-1870) and identified by F. B. Meek, the eminent paleontologist of the old Hayden U. S. Geological Survey. The list of fossils given below is taken from Volume II of the W. Va. Geological Survey (p. 258). The types marked (*) were also collected by the writer in the northern Pan Handle area, and were identified by Dr. J. W. Beede of the University of Indiana, who has made a special study of the Carboniferous invertebrate fossils in the west. Dr. Beede has added to the list as published in the above volume the range of the forms in the Kansas Coal Measure rocks from the basal member, Cherokee shales, to the Permian.

Fossils From Ames Limestone, Near Morgantown.

Orbiculoides missouriensis. **Shum.** Cherokee shales to Elmdale formation.
Productus. Undetermined species. Very small, concentrically wrinkled.
Allorisma. Undetermined species.
Astartella. Undetermined species.
Aviculopecten carbonarius. **Stevens.** Ft. Scott limestone to Howard limestone.
Aviculopecten. Undetermined species. Probably A. occidentalis. **Shumard.**
Myalina ampla. **Meek.** Dennis limestone to Barclay limestone?
Myalina. Undetermined species. Very small. Probably a young shell.
Macrodon obsoletus. **Meek.** Dennis and Lawrence oolite.
Nucula anodontoidea. **Meek.**
Nucula parva. **McChesney.** [Not reported from Kansas, though accredited to the "Upper Coal Measures" at Kansas City, Mo., by Keyes.]
Nucula ventricosa. **Hall.** Cherokee shale to Severy shales.
Nuculana bellistriata attenuata. **Meek.** Cherokee shale to Elmdale formation.
Pseudomonotis. [Probably P hawni.]
Bellerophon percarinatus. **Conrad.** Ft. Scott limestone to Barclay limestone.
Bucanopsis meekianus. **Swallow.**
Euphemus carbonarius. **Cox.** Cherokee shales to Eskridge shales.
Macrocheilus primigenius. **Conrad.**
Macrocheilus ventricosus. **Hall.**
Macrocheilus. Undetermined species.
Pattellostium montfortianum. **Norwood and Pratten.** Cherokee shale to Garrison formation.
Phanerotrema grayvilliensis. **Norwood and Pratten.** Altamont limestone to Barclay limestone?
Pleurotomaria. Undetermined species.
Nautilus. Undetermined species.

Orthoceras cribosum. **Geinitz.** Dennis limestone to Severy shales.
Tainoceras occidentalis. **Swallow.** Ft. Scott limestone to Barclay limestone.
Star shaped crinoid columns.
*Ambocoelia planoconvexa. **Shumard.** Cherokee shales to Florena shales.
*Chonetes granulifera. **Owen.** Cherokee shales to Permian.
*Derbya crassa. **Meek.** Cherokee shales to Permian.
*Productus cora. **d'Orb.** Probably of the Prattenanum variety which is more numerous in the upper part of the Kansas section, while the larger forms are from the lower horizons. Ranges from Cherokee shales to Garrison formation.
*Productus semireticulatus. **Martin.** Cherokee shales to Permian.
*Spirifer cameratus. **Morton.** Cherokee shales to Elmdale formation.
*Productus nebrascensis. **Owen.** Cherokee shales to Permian.

List of Forms From Ames in Pan Handle Area Not Reported From the Morgantown Locality.

Lophophyllum profundum. **M—E. and H.** Cherokee shales to Garrison formation.
Spirorbis cf. anthracosia. **Whitfield.**
Fistulipora sp. undet.
Derbya ? sp. cf. multistriata. **Meek.** cf. Enteletes hemiplicata. **Hall,** the form is crushed and cannot be determined with certainty.
Hustedia mormoni. **Marcou.** Cherokee shales to Garrison formation.
Productus splendens. **Norwood and Pratten.** Cherokee shales to Garrison formation.
Pugnax utah. **Marcou.** Cherokee shales to Garrison formation.
Seminula argentia. **Shepard.** Cherokee shales to Permian.
Spiriferina? kentuckiensis? **Shumard.** (Part of shell shows puncture well.)
Rhipidomella pecosi? **Marcou.** (Imperfect, margin gone.) Fort Scott limestone to Elmdale formation.

Dr. Beede makes the following comments on these fossils from the Ames horizon: "As suggested by Prof. I. C. White,[1] Meek's correlation of this limestone with the beds 1000 to 1500 feet below the Nebraska City beds (probably equivalent to the Topeka limestone and the overlying shales), probably places it too low. The fact which seems so remarkable about this whole fauna is that it is composed almost entirely of species of great vitality which range, as stated by Meek, almost throughout the entire thickness of the western Pennsylvanian. This may be explained by the fact that the time represented by the thin limestone was too short for any but the hardiest species to reach this area before changing conditions caused it to retreat again.

"It will be seen from the inspection of the above lists that nineteen of the species range practically through all the sediments

(*Found also in Pan Handle Area).
1. W. Va. Geol. Survey, Vol. II, p. 260.

of the Kansas Coal Measures, being found, as a rule, wherever favorable conditions have existed any considerable length of time. Four more have almost as great a range, while four others run through over half the strata, the remainder being somewhat more restricted. Five of the species range from the Cherokee shale well into the Permian. One species, *Macrodon obsoletus*, Meek, is found only in the Dennis limestones and the Lawrence oolite.

"However the most instructive point to consider is the time of culmination of the species represented. A few of them do not appear to culminate anywhere, being sparsely scattered through the various formations. Others (at least five) seem to become common or abundant and remain characteristic and important elements of each succeeding horizon where conditions were favorable for their existence. Five become important factors below the Iola limestone, but all five remain so until very much higher horizons are reached. One species, probably represented in the Ames limestone fauna, but too fragmentary to be positively identified, *Spiriferina kentuckiensis* Shumard, culminates in the Iola limestone. *Enteletes hemiplicata* Hall, first appears and culminates in the limestones immediately over the Iola limestone, but continues into the Permian. *Rhipidomella pecosi* Marcou, culminates in the Oread limestone, and *Nuculana bellistriata attenuata* Meek, seems to culminate in the Emporia limestone, though it is fairly abundant in horizons as low as the Labette shales. The remainder of the species are highly developed in numbers for great lengths of time. More of them are in this condition above the Iola limestone than below it. Thirteen of these strong species are at their average height of development in the Oread limestone, and thirteen of them in the Topeka limestone. With one species culminating in the Oread and one below it and one above both the Oread and the Topeka; three assuming an important role in the Oread, one between and two in the Topeka, two dwindling above the Topeka limestone, there is little room for choice in the two general horizons, though the preponderance of evidence would seem to be with a horizon somewhat below that of the Topeka limestones and nearer to that of the Oread limestones. However, further collecting in West Virginia and Ohio from the Ames limestone may change this materially. It may correspond to some horizon anywhere between the Emporia limestone and the Allen limestone. From the evidence at hand I should refer the

Ames limestone roughly to the Shawnee division of the Kansas Pennsylvanian, as that division is limited by Haworth,[1] or the basal part of the Shawnee."

The Harlem (Crinoidal) Coal.

Directly below the Ames limestone, or separated from that stratum by a few feet of shales, is a coal rather persistent in the Pan Handle. It was named by the Pennsylvania Survey the Crinoidal coal, and later by the Maryland Survey, the Friendsville, from its excellent exposure near that town in Garrett county. Dr. J. J. Stevenson has recently called attention to the fact that this coal was earlier named the Harlem coal in Ohio by J. S. Newberry, the name being taken from the town of Harlem in Carroll county, where the coal, 26 to 30 inches thick, was worked in shafts.[2] The coal in this type locality varies from a semi-cannel, open burning variety to a slaty coal of little value. In Maryland this seam reaches a thickness of 28 inches. It has been mined for local use in West Virginia near Newburg, above Clarksburg, and near Burning Springs, 21 to 24 inches thick.

The blossom of the Harlem coal is found below the Ames limestone in many places in the Pan Handle area. It was opened at one time to the west of New Cumberland Junction, where it was 10 inches thick. In the ravine to the south of Osburn mill on Kings creek, the coal forms a projecting ledge, 8 feet below the Ames limestone. It is there 18 inches thick with one foot of black slate over it.

The Pittsburg Red Shale.

Below the Ames limestone and Harlem coal is a series of red and brown shales often with lime nuggets scattered through, and thin layers of sandstone, which form the exposures near Pittsburg was named the Pittsburg Red Shale.

This formation extends across the State of West Virginia, and is known by the oil drillers as the "Big Red Cave." It is a source of much trouble and expense to the driller, who is forced to use especial care in his work through this stratum. As described by Dr. I. C. White (Vol. IV, p. 228), "The wall of the well through this portion of the column of rocks must be quickly lined

1. Univ. Geol. Surv. Kans., III, p. 94, 1898.
2. Bull. Geol. Soc. America, Vol. 17, p. 156, 1906.

with casing or it will cave and crumble into the hole from the pressure of the overlying strata, thus often imprisoning the drilling tools and leading to the abandonment of the boring. The nuggets of hard limestone scattered through these red shales constitute the chief agent of this imprisonment, since they readily tumble out from the walls of the hole, and impinging against the drilling tools, principally at the *jars,* prevent their withdrawal.

"For these reasons every oil well driller becomes an expert stratigrapher in tracing these *red beds* underground, and they have been so traced in hundreds of borings entirely across the state when deeply covered by the overlying Monongahela and Dunkard series, so that whether at the surface and visible in broad bands of red soil around the hills, or buried under 2000 feet of higher sediments, the same deep purple and red shales exist in this portion of the geologic column along the belt of the country west from the mountain region of the state. Hence the color is not the result of recent oxidation, but is evidently due to the deposit of red sediments derived from erosion of old land areas of pre-Carboniferous time."

The Pittsburg Red Shale is found in the Pan Handle area wherever the Ames limestone outcrops. Near that horizon is a bright red clay or shale, but soon changes to a brown and buff color. It is broken by thin strata of sandstone more or less shaly. The best exposure occurs in the river bluffs opposite Steubenville, where its thickness is 120 to 140 feet. It forms a vertical wall along the new river driveway at this point, and by its constant caving has caused much trouble until protected by the construction of long concrete retaining walls, illustrated in plate XI.

The Saltzburg Sandstone.

The Pittsburg red shale is sometimes replaced in part by a heavy sandstone which reaches a thickness of 100 feet near Saltzburg, Westmoreland county, Pa., where it was named by Dr. J. J. Stevenson, the Saltzburg Sandstone.

This rock is present in most of the area of the northern Pan Handle wherever the red shale is exposed. At the mouth of Buffalo creek, below Wellsburg, it forms a wall 27 feet high, though the base of the stratum was not reached. It is here a hard rock, quarried for building stone. The upper 12 feet is a shaly sandstone on the outcrop, while the lower 15 feet is solid.

Opposite Steubenville, the stratum while partly concealed, appears to be 43 feet thick. It is well exposed along the Pennsylvania railroad just west of Colliers town where it is 30 to 40 feet thick, and apparently grades into coarse shales one mile east at Colliers Station, where it is 60 feet below the Ames limestone.

The Bakerstown (Barton) Coal.

A coal seam is found about 100 feet below the Ames limestone, and was named the Bakerstown by Dr. I. C. White from a village in Allegheny county, Pennsylvania. It is known in Maryland as the Barton coal.

This coal was mined for some years at the Blanche mine near Colliers town, Brooke county, on the Pennsylvania railroad, but the mines have been closed for the past two years. Dr. White first identified the Blanche vein at Colliers, and found it to be 370 feet below the Pittsburg coal, 100 feet under the Ames limestone, and 25 to 30 feet above the Upper Cambridge. He describes this coal (Vol. II, p. 267) as, "rather high in sulphur, but as it is low in ash, it gives excellent results as a steam producer. The deposit near Colliers appears to be quite patchy, since in passing eastward the overlying Saltzburg sandstone comes down and cuts out the coal entirely within a short distance from the mine entry. The bed is also thin or poorly represented on the south side of the Pan Handle railroad tracks."

The Bakerstown coal was formerly mined near the head of Hardin run, three-fourths of a mile west of the Pennsylvania state line. The coal was removed by stripping, and it is 90 to 95 feet below the Ames limestone. The coal in the Wheeling Junction section, 134 feet below the Ames horizon, is probably the Bakerstown, though the interval is larger than in other sections.

The Cambridge Limestone.

In typical sections there are at this horizon two limestones often distinguished as Lower and Upper Cambridge, 50 to 100 feet apart. The Upper was called the Pine creek by Dr. I. C. White in Pennsylvania, and the Lower the Brush creek. Dr. J. J. Stevenson has proposed that the Pine creek should be called Cambridge, as named by E. B. Andrews, while the one below retains the name of Brush creek.[1] He further states that the

1. Bull. Geol. Soc. Amer., Vol. 17, p. 157; 1906.

Plate VII.—Pittsburg Coal (A) With Redstone Limestone and Coal Above, in Coal Cut on B. & O. Railroad Near Mount de Chantal, Ohio County.

Cambridge (Pine creek) is the Lower Cambridge of Ohio and that the Upper Cambridge of Ohio, 20 to 30 feet higher, is absent in Pennsylvania and West Virginia.

The Cambridge limestone in the Pan Handle area is 125 feet below the Ames. It is a gray to blue rock usually very fossiliferous, and is sometimes confused with the Ames in sections where but one of these two limestones appear. It is well exposed four feet thick in the hills back of New Cumberland, and in the stream valleys farther east. It forms the bed of Harmon creek below Colliers town, and occurs in a number of the sections south of Kings creek, 125 feet below the Ames. The same interval was found at Wellsburg where the Cambridge limestone is 6 to 10 feet above the river.

The Buffalo Sandstone.

There is sometimes found below the Upper Cambridge limestone a massive sandstone named the Buffalo sandstone from a creek of this name in Butler county, Pennsylvania, by Dr. I. C. White.

This interval in Hancock county holds shales and thin sandstone, but in its typical locality in Butler county the sandstone is 25 feet in thickness, and it is well developed southward through Monongalia and Marion counties, West Virginia.

The Brush Creek Limestone.

This limestone was named from Brush creek in Butler county, Pennsylvania, by Dr. I. C. White, but was later called in that state and West Virginia the Lower Cambridge. Its position is 40 to 90 feet below the Cambridge limestone and it is frequently fossiliferous.

In the Pan Handle area it is often nodular and irregular, and in many sections was not identified. It occurs opposite Steubenville near the level of the new road, 147 feet below the Ames.

The Brush Creek (Mason) Coal.

The Brush creek coal is found just below the limestone or separated from it by a few feet of fossiliferous shales named by Dr. I. C. White the Mason shales. Its horizon is 60 feet above the Mahoning coal near New Cumberland, and 200 to 210 feet below the Ames limestone.

The blossom of this coal occurs in nearly all the sections in

the New Cumberland area. Further north on Mercer run and the creeks east and west, a coal is mined 2 feet 6 inches to 3 feet thick, 200 feet below the Ames, which would be close to the Brush creek horizon though the limestone was not found above the coal.

The Mahoning Sandstone.

Below the Brush creek coal at a variable interval is the heavy Mahoning sandstone, usually separated by shales into two divisions, Upper and Lower, the former being more massive. The Mahoning sandstones are exposed in the river bluffs near New Cumberland and wherever the streams have cut through the Conemaugh Series. The base of the Lower Mahoning sandstone is taken as the lower limit of the Conemaugh Series.

The Mahoning Coal.

Between the two Mahoning sandstones there is sometimes found a coal seam known as the Mahoning coal. It is of economic importance in very few places, as in the New Cumberland region and in Ohio where it is known as the Groff vein.

The Mahoning coal is mined by the Cleveland Coal Co. up Herron run, a branch of Hardin run, back of the town of New Cumberland, and is reached by a switch from the Pennsylvania railroad.

This coal was formerly identified with the Upper Freeport and its proper horizon was determined by Dr. Edw. Orton and Dr. I. C. White. The Upper Freeport coal is thin or wanting in this area, but its limestone and flint fire clay (Bolivar) are present, 20 to 30 feet below the Mahoning coal, which is 145 feet below the Cambridge limestone, or 270 feet below the Ames. The interval from the Mahoning coal to the Lower Freeport or Roger vein, formerly worked in the river hills, is 90 to 120 feet, averaging about 110 feet.

The Mahoning coal in the Marquette mines of the Cleveland Coal Co. is about 5 feet thick. It is very irregular in dip, rising in one mine 28 feet in 200, and is cut out here and there by the overlying sandstone. Below the coal the Mahoning limestone is often found, and in other parts of the state the limestone persists when the coal is absent.

This coal is mined up the creek southeast of Zalia, where it is 3 feet 4 inches in the Swearingen mine. It was mined one mile east of White Oak run, three miles southeast of Congo.

CHAPTER VI.

THE ALLEGHENY SERIES.

The series of rock strata below the Conemaugh was formerly known as the Lower Productive Measures, but was named by H. D. Rogers, the Allegheny, extending to above the Mahoning sandstone. The Allegheny Series, as now recognized by geologists, was first described in 1875 by F. Platt on the Pennsylvania Survey, and extends from the top of the Upper Freeport coal to the top of the Homewood or Tionesta sandstone of the Pottsville Series.

The series is thus described by Dr. I. C. White in volume II of the West Virginia Geological Survey (p. 334): "The Allegheny Series as here limited, is capped at the top with the widely distributed, easily recognized, and valuable Upper Freeport coal bed, and extends down through several beds of fire clay, limestone, coal, shale, and sandstone, until a marked change in lithology takes place, the sandstones becoming harder, more massive, often very pebbly and of a lithologic type quite different from the ordinary sandstones of the Allegheny series, accompanied, of course, with a change in the character of the imbedded fossil plants. The physical change at the base of the series is generally very striking, so that the observer, once familiar with the lithologic type of the Allegheny sediments, finds but slight difficulty in differentiating the basal beds of the latter from the underlying Pottsville.

"The thickness of this Allegheny series varies greatly in different portions of the field. Entering the state from Pennsylvania in Monongalia and Preston counties, the series has in Monongalia a minimum thickness of about 225 feet, which soon expands eastward to 275 to 300 in Preston, and slightly more in Mineral and Grant."

The Allegheny Series is well exposed in the Pan Handle area from Kings creek north, and ranges in thickness from 250 to

275 feet. It contains small coal veins, varying in thickness from a few inches to three feet and a half. It includes thin limestones, valuable seams of fire clay, with heavy sandstones quarried at a few points, and available at many places. The base of the series is more or less concealed by sand and gravel deposited by the river.

The typical sections from the localities where the coals were first named are here given to show the order and character of the rocks of this series. These sections were measured by Dr. I. C. White at Freeport and Kittanning, Pennsylvania.[1]

Section at Freeport, Pennsylvania.

	Ft.	in.
Upper Freeport coal	3	9½
Fire clay	1	6
Limestone, Upper Freeport	3	6
Sandy shales	20	
Coal, Middle Freeport	2	
Sandy shales and sandstone	39	
Coal, Lower Freeport and slate	14	
Fire clay and shales	2	
Sandstone massive	45	
Coaly slate, Upper Kittanning	0	4
Sandstone gray massive	15	
Coal, Middle Kittanning	1	6
Fire clay with limestone nodules in upper half	6	
	155	3½

This section shows a Middle Freeport coal which is not persistent, and is not often reported in other sections. The Lower Freeport is separated into two benches in this section, and in other localities the two parts are separated by several feet of rocks, giving two Lower Freeport coals. The Upper Kittanning coal found in the Freeport section is often absent in other localities.

The section at Kittanning extends to the base of the Allegheny Series, giving a thickness of 315 feet in this locality. The Upper Kittanning coal is apparently absent, but shows in sections five miles below this place.

1. U. S. Geol. Survey, Bull. 65, pp. 109, 111.

Section Near Kittanning, Pennsylvania.

	Ft.	in.
Upper Freeport coal	4	
Shales and concealed	35	
Coal, Lower Freeport	2	
Concealed and massive sandstone	35	
Shales and sandstone	40	
Coal slate in center, Middle Kittanning	1	6
Fire clay	4	
Sandy shales	6	
Fire clay	3	
Flaggy sandstone	17	
Shales dark, sandy, with iron ore	40	
Coal, Lower Kittanning	3	3
Fire clay	5	
Sandstone and sandy shales	40	
Shales with iron ore	5	
Iron ore,Buhrstone	0	6
Limestone, Ferriferous	11	6
Sandy shales	15	
Coal	0	3
Sandy shales and sandstone	21	
Coal, Clarion	1	
Concealed to top of No. XII sandstone	25	
	315	

A very complete section of the Allegheny Series was measured by Dr. I. C. White at the mouth of the Little Beaver river across the Ohio river from the northeastern corner of Hancock county, and might be taken as typical of this series in the northern portion of the Pan Handle area.[1]

Section at Mouth of Little Beaver River, Pennsylvania.

	Ft.	in.	Ft.	in.
Upper Freeport coal	3		53	
Sandy shales	50			
Coal, Lower Freeport	2			
Sandy shales	20		107	
Sandstone, massive	50			
Sandy shales	35			
Coal, Middle Kittanning	2			
Fire clay	5		22	
Shales, with nodules iron ore	15			
Coal, Lower Kittanning	2	6		
Fire clay, Lower Kittanning	10		62	6
Sandy shales and shaly sandstone	50			
Limestone, Ferriferous (Vanport)	1			
Sandy shales	8			
Bituminous shale, Clarion coal	5		29	
Shale, sandy	15			
Massive sandstone, top of Pottsville.				
			273	6

1. W. Va. Geol. Survey, Vol II, p. 380.

This section shows a similar structure and order to the New Cumberland section given on page 42 where the thickness is 287 feet.

A section was measured near Zalia in Hancock county, across from Toronto, Ohio, by Dr. Edward Orton, which shows the relation of the Upper Freeport coal horizon to the Mahoning (Groff) vein above, which has sometimes been mistaken for the lower vein.[1]

Section at Freeman & Co. Works, Hancock County, W. Va.

	Ft.	in.
Groff coal (Mahoning)	3	6
Interval	51	
Limestone, in place of Upper Freeport coal (?)	2	
Shales with ore balls	3	
Non-plastic clay, Bolivar	6	
Shale and sandrock, Upper Freeport	34	
Coal, Lower Freeport (Roger vein)	2	6
Fire clay	3	
Sand rock and sandy shale, Lower Freeport	69	
Coal, 18-inch vein, Middle Kittanning	2	
Fire clay	2	
Sand rock and shale	49	
Coal, Lower Kittanning (Clay vein)	2	
Kittanning clay, mined	6	
Concealed to river	47	

Dr. Edward Orton gives the following diagram showing the intervals between the different coals in Jefferson county, Ohio, the area across the river from Hancock county.[2]

Pittsburg coal (No. 8).	
Interval	175 to 225 feet
Crinoidal (Ames) limestone.	
Interval	120 to 150 feet
Groff (Mahoning) coal (No. 7).	
Interval	40 to 50 feet
Upper Freeport coal (No. 6).	
Interval	35 to 60 feet
Lower Freeport coal (No. 5).	
Interval	40 to 55 feet
Upper Kittanning coal (No. 4—a).	
Interval	30 to 40 feet
Middle Kittanning coal (No. 4).	
Interval	18 to 30 feet
Lower Kittanning coal (No. 3).	
Kittanning clay.	

1. Ohio Geol. Survey, Vol. V, p. 57.
2. Ohio Geol. Survey, Vol. V, p. 53.

A similar skeleton section in Hancock county would show the following intervals:

Pittsburg coal.	
Interval	220 to 250 feet
Ames (Crinoidal) limestone.	
Interval	100 to 130 feet
Cambridge limestone.	
Interval	130 to 150 feet
Mahoning (Groff vein) coal.	
Interval	20 to 30 feet
Upper Freeport coal.	
Interval	65 to 100 feet
Lower Freeport (Roger vein) coal.	
Interval	60 to 80 feet
Middle Kittanning (Block) coal.	
Interval	30 to 35 feet
Lower Kittanning (Clay vein) coal.	
Interval	45 to 60 feet
Clarion coal.	
Interval (estimated)	10 to 20 feet
Top of Pottsville Series.	

This section would give 215 to 300 feet as the interval between the Upper Freeport coal horizon and the Pottsville, or an average of about 260 feet for the thickness of the Allegheny Series.

A section including near all the Allegheny series was measured near the brick plants, two miles north of New Cumberland. The Ferriferous limestone appears in this section as a thin shaly stratum, two to six inches thick but filled with fossils. It apparently changes to calcareous shales in other parts of this area, and is very easily overlooked. The lower clay mined in a few openings occurs a few feet below this limestone and is therefore Clarion, while the clay forming the basis of the main brick industry at New Cumberland is 50 to 80 feet higher, and is the Lower Kittanning.

The fossils from the thin layer of Ferriferous limestone near New Cumberland were sent to Dr. J. W. Beede, who identified them as follows:

Lophophyllum profundum. M-E. and H.
Productus cora? d'Orb. (Variety with the shell wrinkled over the visceral region, too poor to identify with certainty.)
Euphemus carbonarius. Cox.
Spirifer sp. Probably same as a specimen found in the Fort Scott limestone at Fort Scott, Kansas. No others known from that region.

Chonetes mesolobus. N. and P. Cherokee shales to Bethany Falls. ls.
Productus, probably muricatus, Norwood and Pratten, but too poor to identify with certainty.

"The presence of *Chonetes mesolobus* in these rocks at once places them in a horizon well down in the Coal Measures, if we may judge from western faunas. This species is abundant from the Cherokee shale to the floor of the Bethany falls limestone, above which it is practically unknown. This is also borne out by the *Spirifer* and the *Productus* if the latter is correctly identified, as I think it is. Until more of its fauna is known, it could be referred provisionally to the horizon of the Fort Scott limestones, or near them."

The Ferriferous limestone was not found in the preliminary field work for my report on clays (W. Va. Geol. Survey, Vol. III) and an error was made in calling the upper clay vein Middle Kittanning. In the clay report, pages 213 to 219, the Lower Kittanning coal and clay should be called Clarion, while the Middle Kittanning should be Lower Kittanning, but the coal at Kings creek is Middle Kittanning as stated in volume III.

Section North of New Cumberland, Hancock County.

	Ft.	in.	Ft.	in.
Upper Freeport coal horizon.				
Fire clay	8		80	
Shales and thin sandstones	72			
Coal, Roger or Lower Freeport	2	6		
Sandstone, shaly	90		132	6
Sandstone	40			
Coal, Lower Kittanning	2			
Fire clay, Lower Kittanning (mined)	15			
Shales, buff, with iron concretions	55			
Limestone fossiliferous, Ferriferous	0	6	82	7
Black shale clay	0	3		
Shaly limestone with concretions	2	10		
Shales	7			
Coal, Clarion	0	4	10	4
Clay, Clarion (mined)	10			
			315	5

Near Zalia, two miles and a half south of New Cumberland, the strata are exposed from the Lower Kittanning coal and clay to above the top of the Allegheny Series. The Mahoning coal of the Conemaugh is 25 feet above the Upper Freeport, and the Brush creek coal 63 feet higher than the Mahoning.

Section Near Zalia, Hancock County.

	Ft.	in.	Ft.	in.
Upper Freeport coal horizon.				
Limestone, Upper Freeport	2		70	
Flint fire clay, Bolivar	16			
Shales and concealed	52			
Coal, Lower Freeport	2	6	87	
Shales and concealed	25			
Sandstone, cross bedded	10			
Sandstone and concealed	45			
Shales, blue	2	6		
Sandstone	2			
Coal, Middle Kittanning	2	6	33	6
Sandstone and concealed	22			
Coal, Lower Kittanning	2			
Fire clay, Lower Kittanning	7			
			190	6

The following section from the Middle Kittanning coal to the Clarion coal was measured one mile and a half south of Congo at the mines of the old Congo Coal Co. The Middle Kittanning coal here reaches on outcrop a thickness of nearly 7 feet, but decreased to two feet in the mine.

Section South of Congo, Hancock County.

	Ft.	in.	Ft.	in.
Sandstone	20+			
Coal, Middle Kittanning	6	8	6	8
Fire clay	4		31	
Limestone	2			
Sandstone and concealed	25			
Coal, Lower Kittanning	2		45	3½
Fire clay, Lower Kittanning	10			
Shales, blue, with iron nuggets	25			
Shales, sandy	6			
Limestone, hard, Ferriferous	0	½		
Shales, sandy	2			
Black slate	0	3		
Coal, Clarion	0	10	6	10
Shales, buff, sandy	5			
Limestone boulders, blue	1			
			89	9

Near Chester, the Allegheny Series is well exposed on Middle run, in a section from the Upper Freeport Coal horizon to the Lower Kittanning clay, but below this level the rocks are concealed by alluvial sand and gravel.

Section on Middle Run, Near Chester, Hancock County.

	Ft.	in.	Ft.	in.
Upper Freeport coal horizon.				
Limestone, nodular, brecciated, Upper Freeport..	1			
Shale	7			
Flint clay, Bolivar	6			
Shales	8		58	3
Sandstone	6			
Shales and shaly sandstone	24			
Sandstone	6			
Shale	0	3		
Coal, Lower Freeport	2	5		
Fire clay	4			
Limestone, Lower Freeport	2		75	5
Sandstone and concealed	67			
Coal, Middle Kittanning	1	8		
Sandstone	20		28	8
Shales	5			
Black slate	2			
Coal, Lower Kittanning	2	4	12	4
Clay, Lower Kittanning	10			
Interval to Pottsville, estimated from Little Beaver section	80		80	
			254	8

The Upper Freeport coal horizon in this section is 22 feet below the Mahoning coal mined near the head of Middle run, and is 282 feet below the Ames limestone which outcrops in the high knob, one-half mile west.

DESCRIPTION OF THE FORMATIONS.

Upper Freeport Coal.
Upper Freeport Limestone.
Bolivar Fire Clay.
Upper Freeport (Roaring Creek) Sandstone.
Lower Freeport Coal.
Lower Freeport Limestone.
Lower Freeport Sandstone.
Upper Kittanning Coal.
Middle Kittanning Coal.
Lower Kittanning Coal.
Lower Kittanning Clay.
Lower Kittanning Sandstone.
Vanport (Ferriferous) Limestone.
Clarion Sandstone.
Clarion Coal.
Clarion Clay.

The Upper Freeport Coal.

The roof of the Upper Freeport coal is the top of the Allegheny Series. This coal was so named from the town of Freeport, Pennsylvania, by J. P. Lesley in 1856. In that state, Ohio, and West Virginia, it is one of the most important coal seams in the entire Coal Measures, ranking next to the Pittsburg.

The characters of the Upper Freeport coal in its typical development are given as follows by Dr. I. C. White (Vol. III, p. 404): "Unlike the Pittsburg, it does not thin down and vanish to the southwest, but appears to extend entirely across the state, at least along the belt of its eastern crop, and is quite as important in southern Mingo county at the Kentucky line as in eastern Monongalia, and Preston at the Pennsylvania border. * * *

"The character of this coal changes gradually in its passage across the state from a soft, typical coking coal with columnar structure in Monongalia, Preston, Taylor, Barbour, and Randolph, to a harder or *splinty* type, which beginning in southern Upshur and Webster, continues a feature of the coal on southwestward to the Kentucky line, although usually a portion of the bed will contain some layers of soft coal."

The Upper Freeport coal in Maryland is known as the "Four Foot" vein, and is locally called in Mineral and Tucker counties, West Virginia, the Thomas vein. The coal is a valuable coking coal at Austen in Preston county, and on Decker's creek above Morgantown.

This coal has in nearly all exposures a complex structure, being separated into benches by slates as illustrated in the type section at Freeport, where there are three divisions.[1]

	Ft.	in.	Ft.	in
Coal	2	8		
Slate, gray	0	1½		
Coal	0	6½	3	9½
Slate, dark gray	0	½		
Coal, sulphurous	0	5		

The structure of the seam on Decker's creek, Monongalia county, is given as follows:[2]

1. U. S. Geol. Survey, Bull. 65, p. 111.
2. W. Va. Geol. Survey, Vol. II, p. 419.

	Ft.	in.	Ft.	in
Cannel	0	7		
Bone coal	0	8		
Coal, main bench	2	11	5	4
Slate, little	0	2		
Coal, mining ply	1	0		

In Ohio, the Upper Freeport coal is also known as the "Big Vein" No. 6. In the Hocking Valley, where it reaches a thickness of 5 to 7 feet, it shows a variable structure, but the following section is fairly representative:[1]

	Ft.	in.
Roof shale.		
Coal	3	
Clay	1	4
Coal	2	
Clay	—	
	6	4

In contrast with the rich development of this seam in Ohio and many places in West Virginia, is the poor character of the Upper Freeport in the Pan Handle area. It is usually absent, and if present, forms a very thin blossom. Its horizon can only be located and traced by the limestone below and the underlying flint fire clay, which are present over most of the Hancock county area, 20 to 30 feet below the Mahoning coal and 290 feet below the Ames limestone, or 165 feet below the Cambridge.

The Upper Freeport Limestone.

This limestone occurs a few feet below the coal, and is distributed somewhat irregularly through Pennsylvania and Ohio, while in West Virginia it is only reported from Preston, eastern Monongalia, and Hancock counties. It appears to be replaced by the fire clay in Maryland and some sections in Pennsylvania.

The limestone has the following chemical composition near Morgantown on Decker's creek, and in Pennsylvania:

	Decker's creek.	Pennsylvania.[2]
Lime carbonate	88.21	91.98
Magnesium carbonate	3.05	1.66
Silica	3.80	4.01
Alumina and iron	4.97	1.52

1. Ohio Geol. Survey, Vol. V, p. 287.
2. U. S. Geol. Survey. Bull. 249, p. 13.

The thickness of this stratum reaches 10 to 15 feet, but in the New Cumberland area it is 1 to 2 feet, often nodular, and sometimes brecciated. The limestone reaches 4 feet in thickness on the Dornan farm, northeast of New Cumberland, and is there 20 feet below the Mahoning coal.

The Bolivar Fire Clay.

Below the Upper Freeport limestone and replacing it wholly or in part is a bed of flint fire clay named the Bolivar from a town in Westmoreland county, Pennsylvania, where it has long been the basis of an important fire brick industry. It is also a valuable fire clay at a few places in Jefferson and Muskingum counties, Ohio. Outside of New Cumberland it is only reported from one locality in West Virginia, on Decker's creek in Monongalia and Preston counties.

Near New Cumberland this clay varies from 6 to 15 feet in thickness and is a typical flint fire clay, somewhat iron stained on the surface. It has never been worked, but is available at a number of places.

The Upper Freeport (Roaring Creek) Sandstone.

A massive sandstone occurs below the Upper Freeport coal and limestone horizon, which has been named in Pennsylvania the Upper Freeport sandstone, and in Randolph county, West Virginia, the Roaring creek. It is also known as the Butler sandstone.

In Hancock county the interval below the Upper Freeport coal horizon contains shales and thin sandstone strata often shaly or flagstone.

The Lower Freeport Coal.

At an interval of 65 to 100 feet below the Upper Freeport coal is another vein, the Lower Freeport, known locally in the Ohio valley as the Roger Vein, and Steubenville Shaft Vein. In this area it is a much more valuable seam than the Upper Freeport or the coals below it.

This coal is a multiple seam at its type locality of Freeport, Pennsylvania, where it shows the following structure:

	Ft.	in.
Cannel slate	5	
Slaty coal	4	
Fire clay and limestone	2	6
Slaty coal	2	6
	14	

In the New Cumberland region, the Lower Freeport coal occurs 85 to 130 feet below the Mahoning vein, the next coal mined, and 90 to 120 feet above the Lower Kittanning or clay vein. It was formerly mined in the river bluffs from Kings creek to Globe, two miles and a half north of New Cumberland, but all of these mines have been abandoned. It is now mined in a small way up Kings creek, where it is known as the Kings Creek Vein, up the run north of Zalia, also north of Moscow, and south of Chester. The structure of the Lower Freeport coal in this area is quite constant. It is divided by a thin slate into two benches, as shown by the following section near Zalia:

	Ft.	in.
Coal	1	3
Slate	0	½
Coal	1	2
	2	5½

The coal reaches a thickness of five feet up Kings creek and is mined three miles and a half up the stream to beyond Osburn's mill. Dr. Edward Orton gives the following section on the Tarr farm, two miles above the mouth of the creek, which shows the structure of the coal and its relation to the Upper Freeport horizon:[1]

				Ft.	in.	Ft.	in.
Limestone, place of Upper Freeport coal				1	4	30	4
Bolivar fire clay, in pockets				5			
Shale with lime nodules				4			
Shale				20			
Coal, Lower Freeport	Bone coal	0	6	4	8		
	Coal	3	0				
	Slate	0	2				
	Coal	1	0				
Fire clay and concealed to creek				23			

He gives the following summary of the relations of the Lower Freeport coal on Kings creek:

"1. It ranges from 2 to 5 feet in thickness.

"2. It is a little more than 300 feet below the Crinoidal limestone (308 feet on the Tarr farm).

"3. It ranges between 90 and 120 feet above the Lower Kittanning coal.

"4. The Upper Freeport clay and limestone occur about 35 feet above it."

1. Ohio Geol. Survey, Vol. V, p. 58.

The Lower Freeport coal outcrops near the mouth of Kings creek at the top of the Casparis stone quarry where the following section is exposed:

	Ft.	in.
Shales	20	
Coal, Lower Freeport	2	10
Clay and shale	4	
Sandstone, Lower Freeport	80	
Coal, Middle Kittanning	2	8
Fire clay	10	

The coal passes under the river about two miles south of Kings creek. Opposite Steubenville, according to Dr. Newberry, it is 100 feet under the river.

The Lower Freeport coal is mined at the Fulmer mine up Middle run from Chester, where it is 2 feet 5 inches thick. It is 3 feet thick up Dry run above Arroyo, and is 3 to 3½ feet thick on Tomlinson run.

The detailed study made of the Roger vein in Ohio by Dr. Edward Orton and his assistants proves almost conclusively that this vein is the Lower Freeport coal, and is the vein which has been mined in the deep shafts at Steubenville, Mingo, Wellsburg, La Grange, and Rush Run.

The first shaft to this coal was sunk at Steubenville in 1855. The seam has been mined in shafts from Wills creek south to Rush Run, a distance of 10 miles, and has an average thickness of 4 feet. The depth from surface to top of the coal in the various shafts is:

	To top coal.		Thickness of coal. Ft.	in.
Cable shaft, above mouth Wills creek	75	feet.		
Stony Hollow shaft	187½	"	4	6
Market Street shaft	225	"	4	6
Mingo Junction shaft	234	"	3	0
Wellsburg shaft	240	"	4	0
La Grange shaft	261	"	5	3
Rush Run shaft	258	"	7	0

The coal shows its greatest thickness at Rush Run, but in these mines it was variable. At the bottom of the shaft, where it reached 7 feet in thickness, one foot at the top and one foot at the bottom were left on account of high percentage of impurities, so that the workable thickness was 5 feet. The coal dipped to east and northeast in this mine and when followed under the Ohio river reached a thickness of 7 feet of good coal.

The structure of the coal in the Steubenville shaft shows:[1]

	Ft.	in.	Ft.	in.
Blue slate roof.				
Breast coal	3		4	3
Parting	0	1		
Lower bench	1	2		
Fire clay	1			
Limestone	6			
Fire clay	3+			

The Wellsburg shaft was put down in 1884 and abandoned in 1891. The coal was 4 feet thick with a parting 14 inches above the bottom. Dr. Orton reports a 6 inch seam 22 feet above the shaft vein, but the interval decreases until near the Market street shaft it is directly over the shaft vein. In the Wellsburg shaft this little rider vein is 8 inches thick and 14 feet above the coal. Five feet higher is the heavy sandstone.

The Steubenville shaft coal is described by Dr. Edward Orton as follows:[2] "The coal is bright and cubical, but it is of rather a tender nature. Its joints are even and regular, but they are numerous, and divide the coal into small blocks, to which fact its weakness is mainly due. Although a tender coal, it cannot be profitably mined without the use of powder. The result is that it mines small. * * * * Never less than one-third and generally one-half of the coal that is sent from the shaft comes out as slack and nut coal.

"The coal is of the cementing variety, and it makes a coke of fair strength and character. All of the small coal and slack has been utilized in this way hitherto. The amount of visible *sulphur* or pyrite varies in different parts of the seam, and also in different portions of the mines. The bottom bench is more impure than the breast coal, but the larger balls of pyrite lie near the roof. Like the Freeport seams generally, this coal ranges rather high in sulphur."

The Lower Freeport Limestone.

Below the Lower Freeport coal a limestone is present in Pennsylvania, Ohio, and a few localities in West Virginia and Maryland. It resembles the limestone below the Upper Freeport coal, and is usually non-fossiliferous. In Hancock county this

1. Ohio Geol. Survey, Vol. V, p. 217.
2. loc. cit., p. 218.

limestone is present in nodular masses, but north of New Cumberland in the Tomlinson run region, the limestone forms a solid stratum 2 to 4 feet thick, and is blue in color, non-fossiliferous.

The Lower Freeport Sandstone.

Below the Lower Freeport coal is a massive sandstone, the Lower Freeport Sandstone. It forms steep cliffs near New Cumberland, 50 to 100 feet high, and the rocky gorge of Hardin run back of the town. The rock is quarried above the mouth of Kings creek and one mile and a half below New Cumberland.

The rock is buff in color, but in the unweathered portions is blue to gray. It is close grained with fine mica flakes, and at some of the exposures is adapted to manufacture of grind stones. At the Casparis quarry on Kings creek there is a vertical wall of the sandstone, 80 feet in height, and the rock is used for bridge piers, foundation work, and building stone.

In some localities this sandstone divides and a coal, the Upper Kittanning, comes in between the two strata. This coal was not identified in the Pan Handle area.

The Middle Kittanning Coal.

Below the Lower Freeport sandstone is the Middle Kittanning coal, named from Kittanning, in Armstrong county, Pennsylvania. Its horizon is 60 to 80 feet below the Lower Freeport coal.

In Ohio this vein is called in the Hocking Valley the "Great Vein," where its thickness is 6 to 16 feet. The following section represents its structure:[1]

	Ft.	in.
Coal	6	10
Shale	0	4
Coal	1	8
Shale	0	3
Coal	2	0
	11	1

In the Pan Handle area this coal was mined near Zalia, 30 feet above the Lower Kittanning. It outcrops at the mouth of Kings creek and is opened just south of this creek, 30 feet above the river. Less than a mile south the coal passes under the river.

1. Ohio Geol. Survey, Vol. V, p. 698.

Near Holbert's run it was formerly mined with the following structure:

	Ft.	in.
Coal	1	0
Slate, dark	0	1
Coal	1	10
	2	11

In the old mine of the Congo Coal Co., below Congo, the coal was 7 feet thick on outcrop, but soon decreased as followed into the mine. Its structure is similar to that near Kings creek.

	Ft.	in.
Bone coal	0	6
Coal	4	6
Slate	0	2
Coal	1	6
Clay floor.		

The same coal outcrops one foot eight inches in thickness up Middle run, south of Chester. At the present time most of the mines in Middle Kittanning coal have been closed. North of New Cumberland a local limestone, 3 to 4 feet in thickness, occurs below this coal at the old Congo mine.

The Lower Kittanning Coal.

The Lower Kittanning coal occurs 30 to 35 feet below the Middle Kittanning. In the type section at Kittanning, the coal has the following structure:

	Ft.	in.
Coal	1	10
Slate	0	2
Coal	0	8
Bone coal	0	1
Coal	0	6
	3	3

In Maryland, the vein is a mixture of bone coal and coal, 4 feet 4 inches thick.[1]

	Ft.	in.
Coal	0	5
Bone	0	1
Coal	0	5
Bone	0	2
Coal	0	4
Bone	1	0
Coal	1	11
	4	4

1. Md. Geol. Survey, Garrett County, p. 119.

In the New Cumberland area the Lower Kittanning coal is about 2 feet in thickness with a parting near the center, but the coal is overshadowed in value by the underlying fire clay, which reaches 8 to 15 feet in thickness and forms the basis of a large brick and clay industry. In some of the mines the coal is cut out entirely, the overlying sandstone resting on the fire clay. The clay mine entries are driven near the bottom of the clay, leaving the coal high in the roof. The Lower Kittanning clay is only worked in one other locality in the state, near Hammond, in eastern Marion county.

The Vanport (Ferriferous) Limestone.

At an interval of 45 to 80 feet below the Lower Kittanning coal is a limestone horizon which is quite persistent in Pennsylvania, and followed into West Virginia and Ohio. In the latter state it was named by E. B. Andrews from its associated iron ore, the Ferriferous limestone. It was named by Dr. I. C. White, in Pennsylvania, the Vanport.

The Vanport limestone in its outcrop in Preston, Taylor, and Marion counties, is accompanied by iron ore, but in the Pan Handle area the iron ore is apparently absent.

In the New Cumberland and Congo region the limestone is poorly developed, ranging from a few inches to a foot and half in thickness. It grades into a shaly limestone below, so that the solid layer is only 3 to 4 inches, but usually filled with fossils.

The Vanport limestone is well exposed in a thin layer 10 feet above the Clarion coal in the hillside cut back of the Eagle sewer pipe plant north of New Cumberland. The horizon at this place is 60 feet below the Lower Kittanning coal.

The Clarion Coal.

Ten feet below the Vanport limestone occurs the Clarion coal. This coal in the Pan Handle area is thin, 2 to 4 inches, reaching 10 inches south of Congo. Below the coal is a fire clay, 8 to 15 feet in thickness, which is regarded as especially adapted to the manufacture of sewer pipe. In the Congo area the clay is apparently replaced by sandy shales.

In Pennsylvania and Ohio the Clarion coal appears to be split into two veins, the upper being named by Dr. I. C. White the Scrub Grass coal. The character of the formations below the Clarion coal at New Cumberland could not be determined as they are covered by alluvial material. According to the section at the mouth of the Little Beaver river quoted in the early part of this chapter, the bottom of the Clarion clay cannot be far from the bottom of the Allegheny Series. In the deep boring on Dillon creek, in Preston county, the record of which is given in volume II (W. Va. Geol. Survey), p. 344, the Clarion fire clay rests directly on a hard sandstone, the top of the Pottsville Series.

PART III.

The Mineral Resources of the Pan Handle Area.

CHAPTER VII.

THE COAL RESOURCES OF THE PAN HANDLE AREA.

The progress of the last hundred years may be said to rest on a foundation of coal and iron. Coal was considered of little value until near the close of the seventeenth century, and its great development came near the middle of the eighteenth century with the invention of the steam engine, and the use of coal in the smelting of iron ores.

In the words of Dr. J. S. Newberry, "Coal is entitled to be considered as the mainspring of civilization. By the power developed in its combustion all the wheels of industry are kept in motion, commerce is carried on with rapidity and certainty over all portions of the earth's surface, the useful metals are brought from the deep caves in which they have hidden themselves, and are purified and wrought to serve the purposes of man. By coal, night is, in one sense, converted into day, winter into summer, and the life of man, measured by its fruits, greatly prolonged."[1]

The use of coal has resulted in a remarkable saving of labor, since one pound of coal burned in the steam engine is equal to the work of six horses for one hour, or one ton of coal would be equal to the work of 1,200 horses for a day of ten hours. The estimate has been made that the coal used in Great Britain does the work of over a hundred million men.

1. Quoted in Iowa Geol. Survey, Vol. II.

ORIGIN OF COAL.

In past times there has been some dispute as to the origin of coal, but at the present time the vegetable origin of this mineral is accepted by all. The theory that coal was formed from plants was first proposed by a French scientist (Valmont de Bomarre) in 1769, but was not firmly established until the work of the illustrious Swiss naturalist, Leo Lesquereux, in the coal fields of Pennsylvania in 1859.

The proofs for the vegetable origin of coal may be grouped under three heads:

1. Chemical composition.
2. Vegetable structure in coal.
3. Transformation by pressure of vegetable matter into coal.

The chemical composition of coal as revealed by analysis shows the presence of the same elements that are found in wood with a gradual gradation of percentages from anthracite and bituminous coal, through lignite and peat to wood itself. Further, the abundant element in coal is carbon, and the only known source of carbon on a large scale is from plants. They have the unique power in the presence of sunlight of removing the carbonic dioxide gas from the air, and breaking it into its components, retaining the carbon which becomes part of their structure.

When coal is closely examined traces of plant structure may be seen, and thin sections of the coal placed under the microscope reveal to the eye the minute cells and tissues similar to sections of wood. The roof shales are often filled with fossil stems, leaves and even fruits of ancient plants, while the fire clay floor may contain the roots and rootlets of trees which have long ago disappeared from the earth.

Spring, of Belgium, and Daubree, in France, have changed peat and wood into lignite or brown coal by high pressure and the action of superheated steam. In some of the old mines near Clausthal, in the Harz mountains of Germany, which had been abandoned 400 years and reopened, the wood pillars, covered by water and under the pressure of the rocks above, were found to be changed to a lignite coal.

It is now generally believed that the plants which formed the coal accumulated in bogs or swamps similar to modern peat bogs.

Through long periods of time the leaves, twigs, branches, and trunks of trees falling into the swamp would accumulate and decay. Much of the material would be lost and but a remnant would remain. Thus a single coal bed may represent the accumulation of many forests. Sir William Dawson estimated that one foot of coal required for its origin a hundred forests, while Dana stated that five feet of compacted vegetable debris would be necessary to make one foot of bituminous coal.

A study of the fossil plants associated with coal shows that they belong to the groups of ferns, scouring rushes and some cone bearing forms allied to the pines and spruce. Over half of the plants apparently belonged to the group of ferns (Pteridophytes). Some of these forms today represented by small plants six to twelve inches high, grew in those days to the height of 60 feet, with a diameter of 4 to 6 feet. Their roots reached a length of 20 to 30 feet, and from their serpentine form are described by the miner as petrified snakes.

The coal was formed in swamps bordering the old Carboniferous seas. The land at this time was not firm and stable, but it was elevated and depressed, not suddenly, but through long periods of time. With depression the sea would invade the swamp and its deposits of mud, sand, and sometimes lime, would cover the vegetable debris changed or changing into peat and coal. Thus there is found over the coal today a mud shale, a sandstone, or a limestone. Elevation of the land would again restore the conditions of the old swamp and another coal seam be formed. The coal seams may be a fraction of an inch thick or expand to 50 feet and more. There may be a single seam, or through depression and elevation as outlined above there may be a number of separate coal seams one above the other. In Belgium 100 seams are described, in South Wales, according to LeConte, there are over 100 seams, 70 of which are worked. In the Pan Handle counties of West Virginia there are 22 seams with a total thickness of about 54 feet, but not all of this coal is available, since ten of these seams are too thin to be of economic importance.

VARIETIES OF COAL.

Pure carbon is known in nature in the form of graphite and the diamond. They require so high a temperature for their com-

bustion that they are looked upon as non-combustible. Their percentage of fixed carbon is close to 100.

Five varieties of coal with a possible sixth have long been recognized and were separated by the percentage of fixed carbon. In 1877, Persifor Frazer on the Pennsylvania Survey used the fuel ratios (percentage fixed carbon divided by volatile matter) for these groups:

	Fixed carbon.	Fuel ratio.[1]
Anthracite	90 per cent.	100 to 12
Semi-anthracite	85 " "	12 to 8
Semi-bituminous	75 " "	8 to 5
Bituminous	65 " "	5 to 0
Lignite	45 to 50 per cent.	
Peat	Less than 45	

Mr. M. R. Campbell, in the work of the St. Louis fuel testing plant, regards both of these plans of classification as very unsatisfactory. The fuel-ratio classification is defective, according to Mr. Campbell, for two reasons, one that it leaves out of account the lignite or brown coal which is the chief source of fuel supply in many parts of the west. Second, it groups together under bituminous coals the low grade coals of Iowa and Missouri with the great Pittsburg vein and New River coals, which would suggest their equal value.

He has proposed a new classification on the basis of the carbon-hydrogen ratio as determined by the ultimate analysis. It is too soon to predict the successful adoption of this plan, but it rests on a scientific basis and is illustrated later in this chapter.

COAL FIELDS OF THE UNITED STATES.

The bituminous coal fields of the United States have been grouped as follows:

Appalachian Field; Pennsylvania, Ohio, West Virginia, Maryland, Virginia, Eastern Kentucky, Tennessee, Alabama, Georgia.

Area_______70,000 square miles

Northern Interior Field; Michigan.

Area________6,700 square miles

Eastern Interior Field; Illinois, Indiana, Western Kentucky.

Area_______47,000 square miles

1. U. S. Geol. Survey, P.P. 48, Part I, p. 157.

Plate. VIII.—Lower Pittsburg Sandstone With Pittsburg Coal, B. & O. Railroad Cut, Opposite Fulton, Ohio County.

Western Interior Field; Iowa, Nebraska, Missouri, Kansas, Oklahoma, Arkansas, Texas.

Area--------78,000 square miles

Rocky Mountain area.

Of the 201,700 square miles of coal area, probably 125,000 square miles are workable.[1]

The Pan Handle counties include a very small portion of the Appalachian field, which comprises the following areas:[2]

West Virginia	12,930	square miles.
Pennsylvania	11,850	" "
Ohio	8,400	" "
Kentucky	7,300	" "
Tennessee	2,068	" "
Alabama	3,740	" "
Georgia	24	" "
Virginia	1,480	" "
Maryland	408	" "
Total	48,100	square miles.

This great coal field, according to the U. S. Geological Survey, is 800 miles long with its greatest width of 180 square miles near the northern end, tapering to less than 20 miles in Tennessee, then expanding to 80 miles in Alabama, with a total area of coal measure rocks of 70,000 square miles, of which 48,000 are workable.

The greatest single coal seam of the area, and probably the most valuable fuel vein in the world, is the Pittsburg coal, estimated to extend over an area of 14,000 square miles, or allowing for its removal by denudation, reliable geologists have given its original area as 34,000 square miles.

As stated in the St. Louis Fair Hand-book of West Virginia (p. 224): "West Virginia is situated in the very heart of the great Appalachian coal field, of which she has within her borders 17,280 square miles, or more than one-fourth—nearly twenty-eight per cent—of its entire area. This gives 11,059,200 acres, or one thirteenth of the total coal area of the United States; and

1. Based on the estimates of Le Conte.
2. U. S. Geol. Survey, Mineral Resources.

5,200 acres more than the whole area of Great Britain. The coal area is found in 48 of the 55 counties."

HISTORY OF COAL DEVELOPMENT IN WEST VIRGINIA.[1]

The first reference to coal deposits in West Virginia was made by J. P. Salley in 1742, who found the coals along Coal river in the southern part of the State. From time to time travellers and explorers across the Allegheny mountains to the Ohio recorded the existence of coal in various localities. The first record of coal in the Pan Handle area was by Dr. F. A. Michaux, a French botanist, who made a trip from West Liberty, in Ohio county, to Wheeling, July 16, 1802, and stated: "A mile and a half from West Liberty town the road passed through a narrow valley four miles in length, the sides of which in some places from twenty-five to thirty feet in height, exhibit strata of coal from five to six feet in thickness, and lying in a horizontal direction. This substance is extremely common in this part of West Virginia."

Before the year 1810 all the coal used in Wheeling was brought down the river in boats from Pipe creek, on the north side of the Ohio, and its use was almost entirely for blacksmithing purposes. About this time Conrad Cotts, a miner, came to Wheeling from Pittsburg and opened a mine, which he operated for five years, when it caved and was not reopened, but other mines were opened and the coal industry at Wheeling gradually increased.

In 1835 Dr. Samuel P. Hildreth, of Marietta, described the Appalachian coal field of the Upper Ohio valley in the American Journal of Science, which attracted attention to the value of this region. In 1836 Prof. William B. Rogers was sent into the territory west of the Alleghenies to make geological investigations for the state of Virginia. His first work was the tracing of the large vein of coal known as the "Main Coal of Northern Virginia" in the Monongahela valley. After his first report the state provided for a geological survey of Virginia under his direction.

1. Based on article in St. Louis Fair Hand-book of W. Va., p. 225.

In the report for 1837 Rogers wrote: "At Wheeling and for fourteen miles down the Ohio, the cliff or bank of the river presents an uninterrupted bed of highly bituminous coal about ten feet thick. This seam, with some smaller ones, constitutes the Upper Coal Series, the same as that extending throughout the valley of the Monongahela."

STATISTICS OF COAL IN WEST VIRGINIA.[1]

In 1863, the year of the organization of West Virginia as a State, the total coal production was 444,648 tons, which in ten years increased to a million tons. In 1904 the production was 32,406,752 tons, and increased in 1905 to 37,791,580 tons, an increase of 16.6 per cent. The total production of the State from 1863 to close of 1905 is 342,816,606 tons. In 1905 West Virginia held third rank after Pennsylvania and Illinois. Its production was only 642,783 tons less than Illinois, while in 1904 it was 4,068,308 tons less, and in 1906 West Virginia has taken second place, with production estimated by J. W. Paul at 42,500,000 tons.

In 1905 there were 48,389 miners employed in 513 mines in the State, and 1,105 mining machines were in use. The following statistics of the U. S. Geological Survey show the production of coal in the Pan Handle counties from 1901 to close of 1905.

	1901.	1902.	1903.	1904.	1905.
Ohio	191,761	230,241	147,232	118,725	109,201
Brooke	73,198	40,372	35,025	67,706	239,396
Hancock	......	80,400	153,763	79,528	57,683

The following statistics taken from the report of J. W. Paul, Chief Mine Inspector of West Virginia, give the production of these counties from 1888 to 1906:

	1888.	1889.	1890.	1891.	1892.	1893.	1894.
Ohio	137,678	159,664	92,487	80,738	82,534	48,681	49,821
Brooke	17,108	19,203	32,857	33,999	35,046	29,375	32,445

	1895.	1896.	1897.	1898.	1899.	1900.
Ohio	88,691	122,106	95,578	96,912	119,960	96,610
Brooke	50,013	49,623	42,198	56,793	63,176	61,396
Hancock	......	....	33,838	42,870	39,440	47,013

1. Based on reports of U. S. Geol. Survey.

	1901.	1902.	1903.	1904.	1905.
Ohio	115,830	148,852	129,888	101,207	91,752
Brooke	65,904	55,857	24,266	37,804	183,803
Hancock	30,357	38,685	70,495	69,700	58,029

COAL VEINS OF THE PAN HANDLE COUNTIES.

There are in the Pan Handle area 11 workable coal seams with a large acreage, in addition to a number of veins which are too thin to be of economic importance.

The three most important veins are the Pittsburg, Lower Freeport, and Waynesburg. The other valuable seams are, Mahoning, Middle Kittanning, Sewickley, Brush Creek, Bakerstown, Redstone, Lower Kittanning, and Washington.

At the present time only the Pittsburg and Mahoning coals are worked in railroad mines. The other coals could be reached by switches constructed at low cost. These various veins, practically undeveloped over the three counties back from the river, and at many places along the river, represent a vast supply of valuable fuel which is one of the rich assets of the northern Pan Handle.

The stratigraphy of these coals has been given in the preceding chapters, while their chemical composition, heating value, and detailed structure of the seams at the various small mines opened for a local supply form the subject of the present chapter.

The chemical analyses and determination of heating values given in the following pages have been made in the chemical laboratory of the Survey by Leicester Patton and C. S. Forkum under the supervision of the chief chemist of the Survey, Professor B. H. Hite. The coals were sampled by the writer by taking the coal from top to bottom of the vein, discarding the slates and pyrite nodules. The coal was then mixed and divided to secure an average sample, which was placed in a tin can sealed air tight at the mine. These cans on arrival at the Survey laboratory were opened and the coals after air drying were tested in the following manner:

Methods of Analysis.

Coals are examined in two ways known as the proximate and ultimate analysis. In the former method the moisture and ash were determined by heating a weighed quantity of the coal in a

platinum crucible in an air bath for an hour at a temperature of over 100° C., and after cooling, it was weighed and loss represents the moisture. The crucible with the coal sample was then heated over a Bunsen burner until all the combustible matter was removed, and the part remaining weighed as ash.

The volatile combustible matter was determined in accordance with the recommendations of the coal analysis committee appointed by the American Chemical Society. One gram of the coal was heated in a covered platinum crucible for seven minutes over the full flame of a Bunsen burner, and the loss represents volatile combustible matter plus the moisture, the latter component as estimated above is deducted, giving the amount of volatile combustible matter.

The residue is then heated in the crucible with the lid off until all combustible matter is burned out and the loss in weight is the fixed carbon.

In the ultimate analysis the coal is burned in combustion tubes in a current of air and oxygen, and the various products of combustion saved and determined. Sulphur was determined by the Blair method, which was preferred to the Escha method by the Survey chemists. Phosphorus was determined by the regular gravimetric method; and nitrogen by the Kjeldahl method, but the sulphuric acid solution was kept boiling several hours after action seemed to be complete.

The heating values of the coals were determined with the Williams bomb-calorimeter. A weighed amount of the coal is placed in a closed vessel called the "bomb" which is then placed under water. When the coal is burned by electric heat in the bomb the heat from the combustion raises the temperature of the water and this increase in water temperature is a measure of the heating power of the coal, and is expressed in calories or British thermal units.

The proximate analysis separates the coal into the following components: *Fixed carbon* and *volatile combustible matter* which determine the heating value of the coal, *moisture* and *ash* which give no fuel value but are inert parts, *sulphur* which in large quantity may prove injurious in the furnace, eating out grate bars and boiler flues. This is the usual form of coal analyses and a typical coal according to Dr. Edward Orton would contain:

Fixed carbon ---------- 65 per cent.	}	95 per cent.
Volatile combustible matter ---------- 30 " "	}	
Ash ---------------- 2 " "		
Moisture ------------ 2 " "		
Sulphur ------------ 1 " " or less.		

Probably no coal would ever reach this theoretical composition but it will serve as a guide in estimating the value of a given coal, though it should be borne in mind that coals below this grade of purity are still very valuable as fuel.

The percentage of fixed carbon divided by the percentage of volatile matter, gives the fuel ratio, and the heat producing value of a coal increases with increase of this ratio, since the combustion of the fixed carbon produces more heat than the combustion of volatile carbons. According to Dr. W. B. Clark the fuel ratios along the northeastern margin of the Appalachian field vary generally from 3 to 5, while throughout the remainder of the district they range from 1 to 3.[1]

The ultimate analysis separates the coal into its essential chemical elements; carbon, hydrogen, oxygen, nitrogen, sulphur, ash. Its use in determining the value of a given coal is not so apparent to the untrained eye as the proximate analysis, and it is therefore more rarely made and used. It is a more accurate method of analysis, and when such analyses are made over the country they will afford a scientific basis of comparison of the various coals.

The ratio of the various elements to each other can be accurately determined from this form of analysis, which will lead to valuable deductions as to the nature and value of by products that can be obtained. The ultimate analysis is valuable in calculating the heating value of coals without the use of expensive calorimeters. The heating value of the various coals is given in this chapter, as determined by the best form of calorimeter available, and the calculation from the ultimate analysis also given shows a very close agreement in results.

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1. Md. Geol. Survey, Vol. V, p. 239.

The heating value of coal is expressed in terms of calories, or British Thermal Units. In this country the latter term is more commonly used and, therefore, is given in this discussion.

The British Thermal Unit, usually marked B. T. U., represents the number of pounds of water one pound of fuel will raise one degree Fahrenheit, or using the metric system, the calorie represents the number of kilograms of water one kilogram of fuel will raise one degree Centigrade. The heating value of coals expressed in calories can be changed to British Thermal Units by multiplying the number of calories by nine-fifths.

The Pittsburg coal at Fairmont contains about 14,200 B. T. U., and is regarded as one of the best steam coals. The highest calorific value found in the coals of this State is 15,927 B. T. U., in the Pocahontas coal.

Dr. I. C. White (Vol. II, p. 204) states that, "this theoretical heat in the combustion of coal is never attained in actual practice, since combustion of coal is never perfect, and much heat is lost in radiation and imperfect conduction of boiler plates, tubes, etc., and a still larger quantity goes out of the furnace chimney into the air without accomplishing any result, so that but little over half of the heat values locked up in coal are utilized in the heating of water or generation of steam by the ordinary methods."

The coals of the Pan Handle area will now be described in a descending geological order.

COALS IN THE DUNKARD SERIES.

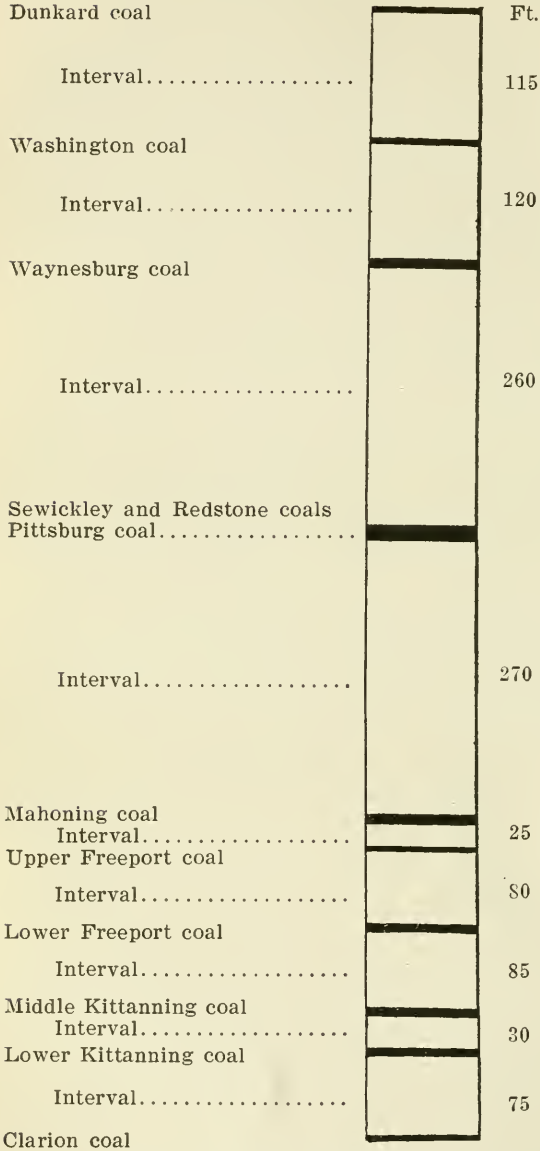


Fig. 2.—Diagram section showing relative position of the coals in the Pan Handle area.

Washington Coal.

The Washington coal in this area is a mixture of thin coals and slates, 8 to 10 feet thick. A sample was taken from a small mine on the John Taggart farm on McGraw's run a half mile west of Valley Grove, Ohio county. The coal was separated from the slate as far as possible, but the analysis shows a very high percentage of ash, proving the coal to be slaty. The second sample was taken from the old mine opened in the 60's for use in the manufacture of coal-oil, and according to the analysis is a bitumінous shale. The deposit is worthless and it was examined on account of its historic interest. The enterprise was unprofitable and the chemical composition would give one good cause for the failure. The material gave no result in the calorimeter and its calculated heating value is very low. While the coal as mined is of better quality, the analysis gives little encouragement for the use of the Washington coal in this area. It might be used for local supply but would not pay for mining if sold in the market.

The Washington coal mined on the Taggart farm shows the following thickness:

	Ft.	in.
Shales	10	
Coal	1	6
Slate	4	
Coal and slate	3	

Its chemical composition is shown by the following analyses:

Loss of moisture on air drying..........1.60 per cent.

Proximate.		Ultimate.	
Fixed carbon	43.10	Carbon	54.00
Volatile matter	28.40	Hydrogen	4.22
Moisture	2.50	Oxygen	8.61
Ash	26.00	Nitrogen	0.87
		Sulphur	6.30
Total	100.00	Ash	26.00
Sulphur	10.05		
Phosphorus	0.018	Total	100.00

Calorimeter, B. T. U..........................10.179

Calculated, B. T. U..........................10.056

Anaylses of above coal calculated to the sample as received, without air drying, would give:

Proximate.		Ultimate.	
Fixed carbon	42.39	Carbon	53.14
Volatile matter	27.95	Hydrogen	4.40
Moisture	4.06	Oxygen	9.80
Ash	25.60	Nitrogen	0.86
		Sulphur	6.20
Total	100.00	Ash	25.60
Sulphur	9.75		
Phosphorus	0.018	Total	100.00

Calorimeter, B. T. U ---------- 10.016

Calculated, B. T. U ---------- 9.952

The slaty coal, wrongly called cannel from the old oil works mine, is 2 feet 6 inches thick with clay floor and 2 feet black slate roof. Its poor composition is shown by the following analyses:

Loss of moisture on air drying ---------- 3.14 per cent.

Proximate.		Ultimate.	
Fixed carbon	17.13	Carbon	21.82
Volatile matter	16.75	Hydrogen	4.11
Moisture	2.25	Oxygen	9.35
Ash	63.87	Nitrogen	0.45
		Sulphur	0.40
Total	100.00	Ash	63.87
Sulphur	0.71		
Phosphorus	0.036	Total	100.00

Calculated B. T. U ---------- 5.013

Analyses corrected to sample as received.

Proximate.		Ultimate.	
Fixed carbon	16.58	Carbon	21.14
Volatile matter	16.23	Hydrogen	4.46
Moisture	5.32	Oxygen	11.70
Ash	61.87	Nitrogen	0.44
		Sulphur	0.39
Total	100.00	Ash	61.87
Sulphur	0.69		
Phosphorus	0.036	Total	100.00

Calculated B. T. U ---------- 4,950

COALS IN THE MONONGAHELA SERIES.

Waynesburg Coal.

The highest stratum in the Monongahela Series is the Waynesburg coal which, according to Dr. I. C. White, is always

high in ash and moisture, the former ranging from 15 per cent upward. It is also high in sulphur and is not regarded as a good steam coal. Its composition in Monongalia county is shown by the following analysis (from Vol. II, p. 147):

Fixed carbon	44.93
Volatile matter	30.04
Moisture	1.69
Ash	23.34
Total	100.00
Sulphur	1.98
Phosphorus	0.012

The Waynesburg coal in the Pan Handle area is higher in sulphur than the one given above, and is high in ash, but usually lower than the Monongalia county coal, and it has generally a higher percentage of fixed and volatile carbon.

The coal outcrops along the various streams of Ohio county back from the river to within three miles of the Pennsylvania line. It is opened in various small banks and the coal is regarded by the farmers of this section as a good domestic fuel. The thickness of the vein will average about two feet and a half. Shales usually form the roof with the heavy Waynesburg sandstone 6 to 10 feet higher.

The Zane bank, worked in the fall and winter, is located just north of the National road at the mouth of Battle run, one mile west of Valley Grove.

The coal shows the following structure:

	Ft.	in.		Ft.	in.
Sandstone roof.					
Clay	2				
Coal	0	3	coal	2	9
Clay	1	2			
Coal	2	6			

Fig. 3.—Coal structure at Zane bank.

The chemical analysis of this coal shows a high percentage of ash and sulphur:

Loss of moisture on air drying..........2.00 per cent

Proximate.		Ultimate.	
Fixed carbon	51.31	Carbon	70.91
Volatile matter	34.00	Hydrogen	4.94
Moisture	1.80	Oxygen	8.51
Ash	12.89	Nitrogen	1.10
		Sulphur	1.65
Total	100.00	Ash	12.89
Sulphur	2.66		
Phosphorus	0.0055	Total	100.00

Calorimeter B. T. U..........12,594

Calculated B. T. U..........12,726

Analyses corrected to sample as received:

Proximate.		Ultimate.	
Fixed carbon	50.28	Carbon	69.49
Volatile matter	33.32	Hydrogen	5.16
Moisture	3.77	Oxygen	10.12
Ash	12.63	Nitrogen	1.08
		Sulphur	1.62
Total	100.00	Ash	12.63
Sulphur	2.61		
Phosphorus	0.0055	Total	100.00

Calorimeter, B. T. U..........12,342

Calculated, B. T. U..........12,594

There are a number of small mines in Waynesburg coal in this section, on Battle, Dixon, and Point runs. Each one gives employment to two to four miners, and they are worked only a few months in the year, and the coal is hauled in wagons to the surrounding country. The introduction of natural gas fuel has greatly decreased the coal consumption in Ohio county, as many of the farmers and residents of the towns are supplied with gas at a low cost.

Mr. R. Phillabaum has opened a mine in the Waynesburg coal on the south side of the National road just above Point Mills. The coal runs 2 feet 6 inches, with a parting near the center, and shale roof. The coal on analysis shows a close agreement with the coal north of the pike at the Zane bank.

Loss of moisture on air drying............1.13 per cent.

Proximate.		Ultimate.	
Fixed carbon	55.25	Carbon	70.91
Volatile matter	31.00	Hydrogen	4.93
Moisture	2.00	Oxygen	9.75
Ash	11.75	Nitrogen	0.96
		Sulphur	1.70
Total	100.00	Ash	11.75
Sulphur	2.70		
Phosphorus	0.0027	Total	100.00

Calorimeter, B. T. U............12,623

Calculated, B. T. U............12,681

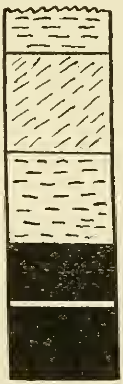
Analyses corrected to sample as received:

Proximate.		Ultimate.	
Fixed carbon	54.62	Carbon	70.11
Volatile matter	30.65	Hydrogen	5.07
Moisture	3.11	Oxygen	10.57
Ash	11.62	Nitrogen	0.95
		Sulphur	1.68
Total	100.00	Ash	11.62
Sulphur	2.67		
Phosphorus	0.0027	Total	100.00

Calorimeter, B. T. U............12,481

Calculated, B. T. U............12,591

One half mile up Dixon run in this same area is the mine of Miller & Lyle where the following section is exposed:



	Ft.	in.	Ft.	in.
Shales.				
Fire clay	2			
Black slate and clay	2	6		
Coal	1	0		
Parting	0	1-16	2	6
Coal	1	6		

Fig. 4.—Coal structure at Miller and Lyle bank.

This coal has the following composition, agreeing closely with the analyses already given for the Waynesburg:

Loss of moisture on air drying............0.12 per cent.

Proximate.		Ultimate.	
Fixed carbon	55.25	Carbon	72.00
Volatile matter	30.70	Hydrogen	4.95
Moisture	2.20	Oxygen	8.50
Ash	11.85	Nitrogen	1.10
		Sulphur	1.60
Total	100.00	Ash	11.85
Sulphur	2.58		
Phosphorus	0.0027	Total	100.00

Calorimeter, B. T. U..........................12,593

Calculated, B. T. U..........................12,949

Analyses corrected to sample as received:

Proximate.		Ultimate.	
Fixed carbon	55.18	Carbon	71.91
Volatile matter	30.66	Hydrogen	4.96
Moisture	2.32	Oxygen	8.59
Ash	11.84	Nitrogen	1.10
		Sulphur	1.60
Total	100.00	Ash	11.84
Sulphur	2.58		
Phosphorus	0.0027	Total	100.00

Calorimeter, B. T. U..........................12,578

Calculated B. T. U..........................12,936

Mr. Gotfried Bope is operating a mine one-half mile up Point run, south of Roney's Point. This mine is worked well back under the hill and furnishes a coal which is held in high favor for household use. Its structure is shown in the following section:

	Ft.	in.		Ft.	in.
Shales	8				
Clay	2				
Black slate	0	8			
Coal	1	6	} coal	2	8
Parting	0	1/8			
Coal	1	0			

The analysis shows 88.29 per cent of carbons and the ash is lower at the other mines.

Loss of moisture on air drying..........0.71 per cent.

Proximate.		Ultimate.	
Fixed carbon	54.94	Carbon	70.36
Volatile matter	33.35	Hydrogen	5.44
Moisture	2.10	Oxygen	11.94
Ash	9.61	Nitrogen	1.25
		Sulphur	1.40
Total	100.00	Ash	9.61
Sulphur	2.20		
Phosphorus	0.0027	Total	100.00

Calorimeter, B. T. U..........................12,773

Calculated, B. T. U..........................12,740

Analyses corrected to sample as received:

Proximate.		Ultimate.	
Fixed carbon	54.56	Carbon	69.86
Volatile matter	33.11	Hydrogen	5.52
Moisture	2.79	Oxygen	12.45
Ash	9.54	Nitrogen	1.24
		Sulphur	1.39
Total	100.00	Ash	9.54
Sulphur	2.18		
Phosphorus	0.0027	Total	100.00

Calorimeter, B. T. U------------------------12,683

Calculated, B. T. U--------------------------12,679

A sample of Waynesburg coal was taken from the John Erskine farm, three-fourths of a mile southeast of Triadelphia and two miles southwest of the Bope mine. The coal here has a limestone roof.

	Ft.	in.
Limestone	10	
Shales	1	
Limestone, gray	0	8
Black slate	1	
Coal	2	6
Shales	3	

A chemical analysis of the coal at this mine shows similar composition to those at the northeast as given above.

Loss of moisture on air drying----------0.30 per cent.

Proximate.		Ultimate.	
Fixed carbon	51.23	Carbon	70.91
Volatile matter	34.85	Hydrogen	4.69
Moisture	2.00	Oxygen	10.17
Ash	11.92	Nitrogen	1.08
		Sulphur	1.25
Total	100.00	Ash	11.92
Sulphur	2.03		
Phosphorus	0.008	Total	100.00

Calorimeter, B. T. U-------------------------12,689

Calculated, B. T. U--------------------------12,466

Analyses corrected to sample as received:

Proximate.		Ultimate.	
Fixed carbon	51.08	Carbon	70.70
Volatile matter	34.75	Hydrogen	4.70
Moisture	2.29	Oxygen	10.39
Ash	11.88	Nitrogen	1.08
		Sulphur	1.25
Total	100.00	Ash	11.88
Sulphur	2.02		
Phosphorus	0.008	Total	100.00

Calorimeter, B. T. U-------------------------12,651

Calculated, B. T. U--------------------------12,442

A small mine has been opened in the Waynesburg coal on Middle Wheeling creek, one-half mile south of Triadelphia and one and three-fourths miles east of Elm Grove. The coal is two feet thick with eight inches of bone coal below. Its composition is shown by the following analyses:

Proximate.		Ultimate.	
Fixed carbon	51.39	Carbon	70.36
Volatile matter	36.60	Hydrogen	5.11
Moisture	1.90	Oxygen	9.52
Ash	10.11	Nitrogen	1.00
		Sulphur	3.90
Total	100.00	Ash	10.11
Sulphur	6.23		
Phosphorus	0.013	Total	100.00

Calorimeter, B. T. U. 13,281
Calculated, B. T. U. 12,787

The farthest north that the Waynesburg coal is mined in Ohio county is three-fourths of a mile south of Potomac, or four miles and a half northeast of the Battle and Dixon run mines. Mr. S. H. Hinerman has opened a small mine on the Masters farm, which shows the following structure:

	Ft.	in.	Ft.
Buff shales	4		
Sandstone	0	8	
Coal	1	2	
Slate	0	1	2
Coal	0	10	

Fig. 5.—Coal structure at Hinerman bank.

The coal is more or less slaty and the analysis shows it to be very high in ash, and does not afford much encouragement for development of this vein in the area south of Potomac. This is the only mine opened in the vein near Potomac and very little coal is taken from it.

Loss of moisture on air drying..........2.77 per cent.

Proximate.		Ultimate.	
Fixed carbon	39.34	Carbon	46.37
Volatile matter	26.30	Hydrogen	5.55
Moisture	2.70	Oxygen	13.84
Ash	31.66	Nitrogen	0.88
		Sulphur	1.70
Total	100.00	Ash	31.66
Sulphur	2.70		
Phosphorus	0.025	Total	100.00

Calorimeter, B. T. U..........................9,477
Calculated, B. T. U..........................9,182

Analyses corrected to sample as received (without air drying).

Proximate.		Ultimate.	
Fixed carbon	38.31	Carbon	45.09
Volatile matter	25.57	Hydrogen	5.86
Moisture	5.33	Oxygen	15.75
Ash	30.79	Nitrogen	0.86
		Sulphur	1.65
Total	100.00	Ash	30.79
Sulphur	2.63		
Phosphorus	0.025	Total	100.00

Calorimeter, B. T. U..........................9,315
Calculated, B. T. U..........................9,037

Excluding this last poor grade of Waynesburg coal, the above analyses would give the average composition of this coal (air dried samples) in the eastern part of Ohio county as follows:

Average Composition Waynesburg Coal, Ohio County.

Proximate.		Ultimate.	
Fixed carbon	53.60	Carbon	71.02
Volatile matter	32.78	Hydrogen	4.99
Moisture	2.02	Oxygen	9.77
Ash	11.60	Nitrogen	1.10
		Sulphur	1.52
Total	100.00	Ash	11.60
Sulphur	2.43	Total	100.00

Calorimeter, B. T. U..........................12,654
Fuel ratio.......................................1.6
Carbon-hydrogen ratio..........................14.2
Carbon-oxygen ratio............................7.2

The above analyses show the Waynesburg coal as sampled to be high in sulphur and ash, with a fair heating value, and the

seam only averages 2 feet and 6 inches in thickness. The samples, however, were taken from small mines as a rule, worked but a short distance into the hills and should be considered as outcrop coals. There remains the possibility of the coal improving in value farther in the hill under a heavier cover. Whether the vein will increase much in thickness when followed into the hill is doubtful. Some well records indicate a much thicker vein, but the coal measurements made in ordinary oil well drilling are not always reliable.

At some future time when the underlying Pittsburg coal is exhausted this seam will certainly be of value, but at the present time its value is to be measured by convenience to the farm owner in securing his own fuel and in supplying his neighbors. The coal could not now be shipped at a profit to compete with other coals in large markets.

The analysis from the Potomac area would indicate that the Waynesburg coal at the north has greatly depreciated, and is of low value, but it would not be fair to judge this area by a single mine sample. Other mines have been opened near Potomac, but have been abandoned and the coal supply is hauled five miles from the Pittsburg coal mines near Bethany.

The Upper Sewickley Coal.

As has been stated in an earlier chapter (IV) the Sewickley coal in Ohio county divides into two seams, Lower and Upper, separated by 10 to 20 feet of shales. The Lower vein is not worked at the present time, and the Upper Sewickley is only used at Triadelphia, though one mine is still open on Peters run, one mile east of Elm Grove.

This vein was formerly opened in a number of mines near Triadelphia, and just east of town reached a thickness of 6 feet in a local basin. The coal is held in high favor in that section, and would probably be largely mined if natural gas was not available.

The only mine of Upper Sewickley coal now working is owned and operated by Sam Knight and is located at the eastern edge of the town of Triadelphia on the south bank of Little Wheeling creek, across from the Baltimore & Ohio railroad. The coal is 3 feet thick, separated from the overlying Benwood limestone by three feet of shales.

Its chemical composition is shown by the following analyses:

Loss of moisture on air drying..........0.70 per cent.

Proximate.		Ultimate.	
Fixed carbon	53.06	Carbon	73.64
Volatile matter	36.08	Hydrogen	5.00
Moisture	1.70	Oxygen	9.67
Ash	9.16	Nitrogen	1.00
		Sulphur	1.53
Total	100.00	Ash	9.16
Sulphur	2.45		
Phosphorus	0.0056	Total	100.00

Calorimeter, B. T. U..........................13,241

Calculated B. T. U..........................13,123

Analyses corrected to sample as received:

Proximate.		Ultimate.	
Fixed carbon	52.70	Carbon	73.13
Volatile matter	35.82	Hydrogen	5.08
Moisture	2.39	Oxygen	10.21
Ash	9.09	Nitrogen	0.99
		Sulphur	1.50
Total	100.00	Ash	9.09
Sulphur	2.45		
Phosphorus	0.0056	Total	100.00

Calorimeter, B. T. U..........................13,148

Calculated B. T. U..........................13,005

Fuel ratio.................................... 1.4

Mr. J. S. Creighton formerly mined the Upper Sewickley coal on his farm, a quarter of a mile up Peter's run, one mile east of Elm Grove. The coal was 1 foot 4 inches thick with a black slate above and below. The slate carries thin coal seams or streaks, and as far as followed into the hill the coal did not increase in thickness. The mine was abandoned and a slope excavated to the Pittsburg coal.

The Upper Sewickley coal at the Creighton bank has the following composition, which shows the slaty character of the vein, very much inferior to the coal at Triadelphia:

Loss of moisture on air drying..........1.37 per cent.

Proximate.		Ultimate.	
Fixed carbon	42.22	Carbon	53.27
Volatile matter	27.20	Hydrogen	4.06
Moisture	1.70	Oxygen	10.11
Ash	28.88	Nitrogen	0.93
		Sulphur	2.75
Total	100.00	Ash	28.88
Sulphur	4.43		
Phosphorus	0.0056	Total	100.00

Calorimeter, B. T. U ---------------------- 9,724
Calculated B. T. U ------------------------- 9,588

Analyses corrected to sample as received:

Proximate.		Ultimate.	
Fixed carbon	41.63	Carbon	52.54
Volatile matter	26.83	Hydrogen	4.21
Moisture	3.05	Oxygen	11.13
Ash	28.49	Nitrogen	0.92
		Sulphur	2.71
Total	100.00	Ash	28.49
Sulphur	4.37		
Phosphorus	0.0056	Total	100.00

Calorimeter, B. T. U ---------------------- 9,591
Calculated B. T. U ------------------------- 9,499

In the vicinity of Elm Grove, Wheeling, and north, this coal has further decreased to 6 to 8 inches in thickness, so that the only outcrop of this coal in workable condition is near Triadelphia. Oil well records indicate its continuity under cover over a large area to the east and south. As the coal decreases in thickness, it apparently becomes high in ash and sulphur. The analysis from the Knight bank shows the coal to be of good grade, and with its thickness of three feet or more, is a valuable coal.

The Pittsburg Coal in Ohio County.

It is the great Pittsburg seam that represents the coal wealth of Ohio and Brooke counties. Outcrops and well records prove that these counties are underlaid with this vein in good thickness, and it is nearly intact, most of the mines being small, and the area worked out is small in comparison with the total area. The amount of cover in the eastern part of Ohio county is about 500 to 600 feet, decreasing westward to its outcrop along the Ohio river and tributary creeks. Practically every oil or gas well drilled in the county finds this vein of coal, recorded 5 to 8 feet in thickness. The total quantity of coal in the two counties and southern part of Hancock has been estimated to be 982,632,400 tons which, at a value of one dollar, would represent a dormant wealth of $982,632,400. Recognizing the great value of this coal to the people of this section a very careful study has been made of the vein and all the mines were examined and many samples tested.

The Pittsburg coal is mined by J. S. Creighton on Peter's run, one mile east of Elm Grove. This is a slope mine with 261 foot incline, while the vertical depth is 88 feet. The mine is equipped with fan, and cable haulage. The coal passes over a small tipple into wagons, and 10 to 12 tons represent the present capacity. The structure is typical of the Pittsburg vein.

	Ft.	in.	Ft.	in
Roof coal	1	8		
Clay	2			
Coal, breast	2	9		
Bands: Slate		1/8		
Bands: Coal	0	3		
Bands: Slate	0	1/8	coal 5	4 3/8
Coal, brick	1	8		
Parting, soot seam	0	1/8		
Coal, bottom	0	8		

Fig. 6.—Coal structure at Creighton mine.

The Creighton shaft coal has the following composition:

Loss of moisture on air drying .... 4.11 per cent.

Proximate.		Ultimate.	
Fixed carbon	52.63	Carbon	70.77
Volatile matter	36.00	Hydrogen	5.55
Moisture	1.90	Oxygen	10.43
Ash	9.47	Nitrogen	1.03
		Sulphur	2.75
Total	100.00	Ash	9.47
Sulphur	4.42		
Phosphorus	0.008	Total	100.00

Calorimeter, B. T. U 12,931

Calculated B. T. U 13,060

Analyses corrected to sample as received:

Proximate.		Ultimate.	
Fixed carbon	50.49	Carbon	67.66
Volatile matter	34.52	Hydrogen	6.01
Moisture	5.93	Oxygen	13.64
Ash	9.06	Nitrogen	0.99
		Sulphur	2.64
Total	100.00	Ash	9.06
Sulphur	4.24		
Phosphorus	0.008	Total	100.00

Calorimeter, B. T. U. ---- 12,400
Calculated B. T. U. ---- 12,632

At Elm Grove the Pittsburg coal is mined in a shaft 65 feet deep to the bottom of the vein. This mine was examined and sampled by A. P. Brady in preparation for the coal report, volume II of the West Virginia Geological Survey. The structure of the seam and the chemical analysis are taken from that report (pp. 197, 205):

	Ft.	in.	Ft.	in.
Roof coal	2	0		
Over clay	1	6		
Breast coal	2	3		
Bands	0	4	5	½
Brick coal	1	8		
Bottom coal	0	9½		

The chemical composition was determined as:

Fixed carbon	50.88
Volatile matter	41.15
Moisture	0.97
Ash	7.00
Total	100.00
Sulphur	3.67
Phosphorus	0.0025

The Pittsburg coal is mined by P. Stark a quarter mile up the run, east of Edgington (Whitfield), one mile and half east of Wheeling. The Stark bank shows the following structure:

	Ft.	in.	Ft.
Roof coal	1	6	
Over clay	1	0	
Breast coal	2	2	
Bands {Parting, Coal, Parting}	0	4	5
Bottom coal	2	6	

Its chemical composition is:

Loss of moisture on air drying..........0.90 per cent.

Proximate.		Ultimate.	
Fixed carbon	54.31	Carbon	71.73
Volatile matter	36.80	Hydrogen	6.11
Moisture	2.20	Oxygen	12.73
Ash	6.69	Nitrogen	1.09
		Sulphur	1.65
Total	100.00	Ash	6.69
Sulphur	4.23		
Phosphorus	0.0056	Total	100.00

Calorimeter, B. T. U..........................13,330

Calculated B. T. U..........................13,302

Analyses corrected to sample as received:

Proximate.		Ultimate.	
Fixed carbon	53.81	Carbon	71.09
Volatile matter	36.48	Hydrogen	6.21
Moisture	3.08	Oxygen	13.35
Ash	6.63	Nitrogen	1.08
		Sulphur	1.64
Total	100.00	Ash	6.63
Sulphur	4.19		
Phosphorus	0.0056	Total	100.00

Calorimeter, B. T. U..........................13,210

Calculated, B. T. U..........................13,231

At the mine of Jacob Hilton, up Stackyard Hollow, near the National road, a half mile east of Fulton, and one mile and a half west of the last mine, the coal has the following structure:

	Ft.	in.	Ft.	in.
Roof coal	1	6		
Over clay or slate	2	0		
Breast coal	2	0		
Bands	0	4	5	4
Brick coal	1	7		
Bottom coal	1	5		

This coal yields the following percentages:

Loss of moisture on air drying..........0.80 per cent.

Proximate.		Ultimate.	
Fixed carbon	54.58	Carbon	72.68
Volatile matter	37.20	Hydrogen	6.39
Moisture	2.30	Oxygen	12.17
Ash	5.92	Nitrogen	0.94
		Sulphur	1.90
Total	100.00	Ash	5.92
Sulphur	3.01		
Phosphorus	0.01	Total	100.00

Calorimeter, B. T. U..........................13,729

Calculated, B. T. U..........................13,667

Analyses corrected to sample as received:

Proximate.		Ultimate.	
Fixed carbon	54.15	Carbon	72.10
Volatile matter	36.90	Hydrogen	6.48
Moisture	3.08	Oxygen	12.74
Ash	5.87	Nitrogen	0.93
		Sulphur	1.88
Total	100.00	Ash	5.87
Sulphur	2.99		
Phosphorus	0.01	Total	100.00

Calorimeter, B. T. U 13,620

Calculated, B. T. U 13,595

The following data on structure and chemical analyses of the Pittsburg coal in the vicinity of Wheeling, are taken from the coal report (volume II, pp. 197, 205). The Jocklum, Whittaker, McKinley, and Manchester mines are located in East Wheeling, the Boggs Run mine is near Benwood.

Structure Pittsburg Coal Near Wheeling.

	Jocklum		Whittaker		McKinley		Manchester		Boggs Run	
	Ft.	in.	Ft.	in.	Ft.	in.	Ft.	in.	Ft.	in.
Roof coal	1	0	1	3	1	0	1	8	1	6
Over clay	1	0	1	0	1	4	1	6	0	1
Breast coal	1	10½	1	11½	1	11	1	11½	2	6
Bands	0	3	0	3½	0	4½	0	5	0	6
Brick coal	1	5	1	3	no parting		no parting		1	7
Bottom coal	1	3	1	1	2	9	2	8	1	6
Total thickness of coal mined	4	9½	4	7	5	½	5	½	6	1

The chemical composition of these coals as given in the volume quoted is:

	Jocklum.	Whittaker.	McKinley.	Manchester.	Boggs Run.
Fixed carbon	53.65	50.66	50.86	52.03	50.35
Volatile matter	40.69	40.19	40.65	39.40	39.40
Moisture	0.90	0.58	0.58	1.07	0.69
Ash	4.76	8.57	7.91	7.50	9.56
Total	100.00	100.00	100.00	100.00	100.00
Sulphur	3.02	3.98	3.32	2.97	4.29
Phosphorus	0.0065	0.005	0.0095	0.0045	0.0045

At the Richland mine, two miles north of North Wheeling, on the river bluff, 145 feet above low water, A. P. Brady found the following structure (Vol. II, p. 198):

	Ft.	in.	Ft.	in.
Roof coal	0	8		
Draw slate	0	6		
Breast coal	1	11		
Bands	0	4½		
Brick coal	1	4	4	10½
Sulphur streak	0			
Bottom coal	1	3		

Fig. 7.—Coal structure at Richland mine.

The chemical composition of this coal is (Vol. II, p. 205):

Fixed carbon	51.36
Volatile matter	37.32
Moisture	1.44
Ash	9.88
Total	100.00
Sulphur	3.41
Phosphorus	0.0105

A number of small mines are open on Short Creek in the northwestern part of Ohio county, west of Shannon. At the Frank Tolman mine, near farm road to south, a quarter mile west of Shannon, the Pittsburg coal is eight feet above the creek and shows the following structure:

	Ft.	in.	Ft.	in.
Roof coal	0	6		
Draw slate	0	10		
Breast coal	2	4		
Bands	0	8	5	2
Bottom coal	2	2		

Fig. 8.—Coal structure at Tolman bank.

Its chemical composition is:

Loss of moisture on air drying__________1.31 per cent.

Proximate.		Ultimate.	
Fixed carbon	55.68	Carbon	73.09
Volatile matter	36.25	Hydrogen	5.67
Moisture	1.30	Oxygen	11.32
Ash	6.77	Nitrogen	1.05
		Sulphur	2.10
Total	100.00	Ash	6.77
Sulphur	3.36		
Phosphorus	0.0028	Total	100.00

Calorimeter, B. T. U________________________13,537

Calculated, B. T. U_________________________13,357

Analyses corrected to sample as received.

Proximate.		Ultimate.	
Fixed carbon	54.96	Carbon	72.14
Volatile matter	35.77	Hydrogen	5.82
Moisture	2.59	Oxygen	12.25
Ash	6.68	Nitrogen	1.04
		Sulphur	2.07
Total	100.00	Ash	6.68
Sulphur	3.32		
Phosphorus	0.0028	Total	100.00

Calorimeter, B. T. U______________________ 13,460

Calculated, B. T. U________________________ 13,237

A quarter mile further west is the W. W. Shannon mine, 22 feet above the creek. The thickness of the coal in this mine is four feet, with the bands reduced to three inches. The composition of the vein is shown by the following analyses:

Loss of moisture on air drying_________ 1.48 per cent.

Proximate.		Ultimate.	
Fixed carbon	58.69	Carbon	73.36
Volatile matter	33.30	Hydrogen	5.78
Moisture	2.15	Oxygen	12.02
Ash	5.86	Nitrogen	1.08
		Sulphur	1.90
Total	100.00	Ash	5.86
Sulphur	3.05		
Phosphorus	0.0056	Total	100.00

Calorimeter, B. T. U______________________ 13,604

Calculated, B. T. U________________________ 13,395

Analyses corrected to sample as received.

Proximate.		Ultimate.	
Fixed carbon	57.81	Carbon	72.28
Volatile matter	32.81	Hydrogen	5.94
Moisture	3.60	Oxygen	13.07
Ash	5.78	Nitrogen	1.06
		Sulphur	1.87
Total	100.00	Ash	5.78
Sulphur	3.01		
Phosphorus	0.0056	Total	100.00

Calorimeter, B. T. U. 13,403
Calculated, B. T. U. 13,261

The William Murray mine is located on the Busby farm on Souttell run a short distance above its mouth, and one mile west of Shannon. Like all the Short creek mines, it is small, giving employment to a couple of miners in the winter season. The structure of the seam is similar to the other mines.

	Ft.	in.	Ft.	in.
Roof coal	0	8		
Draw slate	1			
Breast coal	1	8		
Bands	0	4	4	2
Bottom coal	2	2		

Its chemical composition is:

Loss of moisture on air drying........ 1.60 per cent.

Proximate.		Ultimate.	
Fixed carbon	55.16	Carbon	73.64
Volatile matter	36.00	Hydrogen	5.55
Moisture	2.15	Oxygen	11.37
Ash	6.69	Nitrogen	1.05
		Sulphur	1.70
Total	100.00	Ash	6.69
Sulphur	2.70		
Phosphorus	0.0028	Total	100.00

Calorimeter, B. T. U. 13,463
Calculated, B. T. U. 13,334

Analyses corrected to sample as received.

Proximate.		Ultimate.	
Fixed carbon	54.27	Carbon	72.47
Volatile matter	35.43	Hydrogen	5.73
Moisture	3.72	Oxygen	12.56
Ash	6.58	Nitrogen	1.03
		Sulphur	1.63
Total	100.00	Ash	6.58
Sulphur	2.66		
Phosphorus	0.0028	Total	100.00

Calorimeter, B. T. U. 13,248
Calculated, B. T. U. 13,187

The average composition of the Pittsburg coal in Ohio county determined by the 13 proximate and the six ultimate analyses above is:

Proximate.		Ultimate.	
Fixed carbon	54.64	Carbon	72.54
Volatile matter	36.67	Hydrogen	5.85
Moisture	1.76	Oxygen	11.67
Ash	6.93	Nitrogen	1.04
		Sulphur	2.00
Total	100.00	Ash	6.90
Sulphur	3.41		
		Total	100.00

Calorimeter, B. T. U. 13,432

The Pittsburg Coal in Brooke County.

Two miles and a quarter south of Wellsburg and fourteen miles north of Wheeling is located the Big Four mine of the Brown Coal Company, 340 feet above the Ohio river. A. B. Brady measured the following section of the coal at this mine (Vol. II, p. 198):

	Ft.	in.	Ft.	in.
Roof coal	0	5		
Draw slate	1	2		
Breast coal	1	11		
Bands	0	4		
Brick coal	1	0	4	3
Slate	Trace			
Bottom coal	1	0		

Its chemical composition is shown by the following analyses (Vol. II. p. 205):

Fixed carbon	53.53
Volatile matter	35.18
Moisture	0.78
Ash	10.51
Total	100.00
Sulphur	4.47
Phosphorus	0.007

The structure of the Lewis mine, one-half mile south of Wellsburg and 355 feet above the river, is given as follows by A. P. Brady (Vol. II, p. 199):

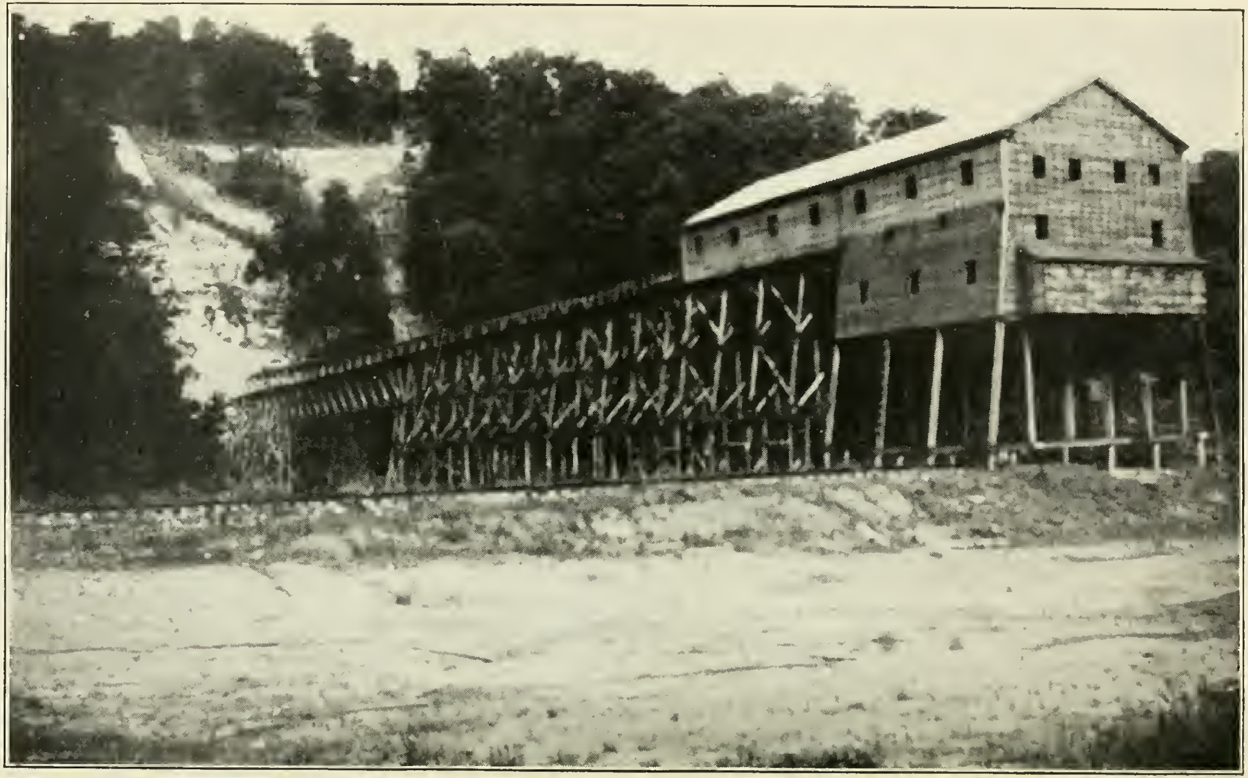


Plate IX.—Pittsburg Coal and Tipple East of Wellsburg, Brooke County.

	Ft.	in.	Ft.	in.
Roof coal	0	5		
Draw slate	1	2		
Breast coal	2	8½		
Bands	0	5		
Brick coal	1	0	5	1½
Slate	Trace			
Bottom coal	1	0		

Fig. 9.—Coal structure at Lewis mine.

Its chemical composition is (Vol. II. p. 205):

Fixed carbon	50.63
Volatile matter	39.42
Moisture	0.63
Ash	9.32
Total	100.00
Sulphur	4.43
Phosphorus	0.012

In southeastern Brooke county the Pittsburg coal outcrop goes under Buffalo creek about a mile east of Bethany. The coal has been mined for many years in this vicinity and the mines supply the farmers of southeastern Brooke and northeastern Ohio counties with fuel.

One-half mile southeast of Bethany on the Barclay farm on Castleman run is a mine operated by Fritz Dowden. The coal has the following structure:

	Ft.	in.	Ft.	in.
Roof coal	0	6		
Draw slate	1	0		
Breast coal	2	9		
Bands	0	3	5	1
Bottom coal	2	1		

Its composition is given by the following analyses:

Loss of moisture on air drying---------- 1.91 per cent.

Proximate.		Ultimate.	
Fixed carbon	54.18	Carbon	70.91
Volatile matter	31.78	Hydrogen	4.56
Moisture	2.12	Oxygen	9.05
Ash	11.92	Nitrogen	1.01
		Sulphur	2.55
Total	100.00	Ash	11.92
Sulphur	4.13		
Phosphorus	0.011	Total	100.00

Calorimeter, B. T. U------------------------ 12,698

Calculated, B. T. U------------------------- 12,544

Analyses corrected to sample as received.

Proximate.		Ultimate.	
Fixed carbon	53.12	Carbon	69.57
Volatile matter	31.18	Hydrogen	4.77
Moisture	4.00	Oxygen	10.47
Ash	11.70	Nitrogen	0.99
		Sulphur	2.50
Total	100.00	Ash	11.70
Sulphur	4.05		
Phosphorus	0.011	Total	100.00

Calorimeter, B. T. U------------------------ 12,456

Calculated, B. T. U------------------------- 12,376

The James Bell mine is located three-fourths mile east of Bethany on the little run to the north of the pike. It shows the following structure:

	Ft.	in.	Ft.	in.
Roof coal	0	4		
Draw slate	1	0		
Breast coal	2	6		
Bands	0	3½	4	2½
Bottom coal	1	5		

Its chemical composition is:

Loss of moisture on air drying---------- 1.36 per cent.

Proximate.		Ultimate.	
Fixed carbon	51.48	Carbon	72.00
Volatile matter	36.42	Hydrogen	5.00
Moisture	2.03	Oxygen	10.12
Ash	9.07	Nitrogen	1.06
		Sulphur	2.75
Total	100.00	Ash	9.07
Sulphur	4.38		
Phosphorus	0.0042	Total	100.00

Calorimeter, B. T. U------------------------ 13,243

Calculated, B. T. U------------------------- 12,890

Analyses corrected to sample as received.

Proximate.		Ultimate.	
Fixed carbon	52.86	Carbon	71.02
Volatile matter	35.83	Hydrogen	5.15
Moisture	3.36	Oxygen	11.11
Ash	8.95	Nitrogen	1.05
		Sulphur	2.72
Total	100.00	Ash	8.95
Sulphur	1.32		
Phosphorus	0.0042	Total	100.00

Calorimeter, B. T. U ---------- 13,063
Calculated, B. T. U ---------- 12,780

Bethany college owns a mine just back of the Campus and at the western edge of town. This mine was locked at the time visited and could not be examined. An attempt was made to secure an average sample from the blocks on a recent dump at the mine platform and the following analyses were made from this material. While such a sample is not reliable as an average, its analyses agree fairly well with the coal taken from the Beck mine, three-fourths mile west. The loss on air drying as compared with other mine samples shows that the coal has lost part of its moisture while on the platform:

Loss of moisture on air drying ---------- 0.55 per cent.

Proximate.		Ultimate.	
Fixed carbon	57.98	Carbon	73.19
Volatile matter	33.91	Hydrogen	4.67
Moisture	1.89	Oxygen	12.94
Ash	6.22	Nitrogen	1.13
		Sulphur	1.85
Total	100.00	Ash	6.22
Sulphur	2.99		
Phosphorus	0.0028	Total	100.00

Calorimeter, B. T. U ---------- 12,696
Calculated, B. T. U ---------- 12,609

Analyses corrected to sample as received.

Proximate.		Ultimate.	
Fixed carbon	57.66	Carbon	72.79
Volatile matter	33.72	Hydrogen	4.73
Moisture	2.43	Oxygen	13.33
Ash	6.19	Nitrogen	1.12
		Sulphur	1.84
Total	100.00	Ash	6.19
Sulphur	2.97		
Phosphorus	0.0028	Total	100.00

Calorimeter, B. T. U 12,628
Calculated, B. T. U 12,548

The Pittsburg coal at the Taylor mine on the Calvin Beck farm on the south side of Buffalo creek, one mile southwest of Bethany, has the following structure:

	Ft.	in.	Ft.	in.
Roof coal	0	4		
Draw slate	1	0		
Breast coal	2	3		
Bands	0	4	4	10
Bottom coal	2	3		

Fig. 10.—Coal structure at Taylor bank.

Its chemical composition is shown by the following analyses:

Loss of moisture on air drying .... 1.22 per cent.

Proximate.		Ultimate.	
Fixed carbon	58.63	Carbon	73.64
Volatile matter	32.85	Hydrogen	5.55
Moisture	2.45	Oxygen	11.69
Ash	6.07	Nitrogen	1.05
		Sulphur	2.00
Total	100.00	Ash	6.07
Sulphur	3.23		
Phosphorus	0.0056	Total	100.00

Calorimeter, B. T. U 13,593
Calculated, B. T. U 13,327

Analysis corrected to sample as received (not air dried).

Proximate.		Ultimate.	
Fixed carbon	57.92	Carbon	72.74
Volatile matter	32.45	Hydrogen	5.69
Moisture	3.63	Oxygen	12.55
Ash	6.00	Nitrogen	1.04
		Sulphur	1.98
Total	100.00	Ash	6.00
Sulphur	3.19		
Phosphorus	0.0056	Total	100.00

Calorimeter, B. T. U 13,427
Calculated, B. T. U 13,282

The Pittsburg coal mine of T. W. Carmichael is 162 feet above the Bethany pike level and three miles southeast of Wellsburg and one-half mile south of Pierce run. The vein has the following structure:

	Ft.	In.	Ft.	in.
Roof coal	0	8		
Draw slate	1			
Breast coal	3			
Bands	0	9	6	9
Bands	3			

Its chemical composition is:

Loss of moisture on air drying---------- 1.24 per cent.

Proximate.		Ultimate.	
Fixed carbon	57.83	Carbon	72.55
Volatile matter	33.45	Hydrogen	5.44
Moisture	2.25	Oxygen	11.96
Ash	6.47	Nitrogen	1.08
		Sulphur	2.50
Total	100.00	Ash	6.47
Sulphur	4.01		
Phosphorus	0.0056	Total	100.00

Calorimeter, B. T. U-------------------------- 13,567

Calculated, B. T. U--------------------------- 13,158

Analyses corrected to sample as received.

Proximate.		Ultimate.	
Fixed carbon	57.11	Carbon	71.65
Volatile matter	33.04	Hydrogen	5.58
Moisture	3.46	Oxygen	12.84
Ash	6.39	Nitrogen	1.07
		Sulphur	2.47
Total	100.00	Ash	6.39
Sulphur	3.96		
Phosphorus	0.0056	Total	100.00

Calorimeter, B. T. U-------------------------- 13,400

Calculated, B. T. U--------------------------- 12,990

A small mine has been opened in the Pittsburg coal on the Matthew Hindman farm, one mile up Pierce run, east of the Bethany pike, three miles southeast of Bethany, and a mile and a quarter northeast of the Carmichael mine. The following structure was measured:

	Ft.	in.	Ft.	in.
Roof coal	0	3		
Draw slate	1	0		
Breast coal	2	0		
Bands	0	6	4	6
Bottom coal	2	0		

Fig. 11.—Coal structure at Hindman bank.

The coal has the following chemical composition:

Loss of moisture on air drying.......... 1.43 per cent.

Proximate.		Ultimate.	
Fixed carbon	54.79	Carbon	70.36
Volatile matter	30.35	Hydrogen	4.67
Moisture	2.70	Oxygen	10.00
Ash	12.16	Nitrogen	1.01
		Sulphur	1.80
Total	100.00	Ash	12.16
Sulphur	2.87		
Phosphorus	0.014	Total	100.00

Calorimeter, B. T. U.......................... 12,408

Calculated, B. T. U.......................... 12,420

Analyses corrected to sample as received.

Proximate.		Ultimate.	
Fixed carbon	54.00	Carbon	69.36
Volatile matter	29.92	Hydrogen	4.83
Moisture	4.09	Oxygen	11.04
Ash	11.99	Nitrogen	1.00
		Sulphur	1.78
Total	100.00	Ash	11.99
Sulphur	2.83		
Phosphorus	0.014	Total	100.00

Calorimeter, B. T. U.......................... 12,231

Calculated, B. T. U.......................... 12,299

One mile east of Wellsburg on the Waynesburg pike on the Frank Jacobs farm is a mine operated by J. C. Cram, one of the pioneer coal operators of the Ohio valley. Mr. Cram has made a model mine and employs five miners in the winter, the mine output

amounting to 7,000 tons a year, which is hauled to Wellsburg and used at the Riverside glass plant and for household fuel. The mine is 996 feet above mean tide level, and has been opened 14 years. The main entry is driven 1,000 feet under the hill and has numerous lateral workings. The coal reaches six feet in thickness and has the following structure:

	Ft.	in.	Ft.	in.
Roof coal	0	10		
Draw slate	1	0		
Breast coal	3	1		
Bands { Slate 1 In., Coal 3 In., Slate 1 In. }	0	5	5	10
Brick coal	1	3		
Sulphur parting	0	1		
Bottom coal	1			

Fig. 12. Structure of coal at Cram mine.

The composition of this coal 1,000 feet in the hill is:

Loss of moisture on air drying......... 0.70 per cent.

Proximate.		Ultimate.	
Fixed carbon	54.56	Carbon	71.45
Volatile matter	33.25	Hydrogen	5.00
Moisture	2.85	Oxygen	11.81
Ash	9.34	Nitrogen	1.00
		Sulphur	1.40
Total	100.00	Ash	9.34
Sulphur	2.20		
Phosphorus	0.007	Total	100.00

Calorimeter, B. T. U......................... 12,950

Calculated, B. T. U......................... 12,614

Analyses corrected to sample as received.

Proximate.		Ultimate.	
Fixed carbon	54.17	Carbon	70.95
Volatile matter	33.02	Hydrogen	5.08
Moisture	3.53	Oxygen	12.31
Ash	9.28	Nitrogen	0.99
		Sulphur	1.39
Total	100.00	Ash	9.28
Sulphur	2.18		
Phosphorus	0.007	Total	100.00

Calorimeter, B. T. U............................ 12,860
Calculated, B. T. U............................ 12,541

The Tom Brown mine is located on the Wilson farm one-half mile northeast of the Cram mine, one mile and a quarter east of Wellsburg. The structure of the Pittsburg vein at this mine was measured as:

	Ft.	in.	Ft.	in.
Roof coal	0	4		
Draw slate	0	10		
Breast coal	1	4		
Bands	0	3	4	5
Bottom coal	2	10		

Its chemical composition was determined as:

Proximate.		Ultimate.	
Fixed carbon	56.32	Carbon	77.36
Volatile matter	37.20	Hydrogen	5.33
Moisture	1.70	Oxygen	9.78
Ash	4.78	Nitrogen	1.00
		Sulphur	1.45
Total	100.00	Ash	4.78
Sulphur	2.34		
Phosphorus	0.008	Total	100.00

Calorimeter, B. T. U............................ 13,731
Calculated, B. T. U............................ 13,862

The Gilchrist mine, located one mile north of Lazearville, Brooke county, was measured by A. P. Brady (Vol. II, p. 199):

	Ft.	in.	Ft.	in.
Roof coal	0	5		
Draw slate	1	2		
Breast coal	2	1½		
Bands	0	4	4	8
Bottom coal	2	2½		

Fig. 13. Coal structure at Gilchrist mine.

The chemical composition was determined as (Vol. II, p. 205):

Fixed carbon	51.59
Volatile matter	37.45
Moisture	0.95
Ash	10.01
Total	100.00
Sulphur	4.25
Phosphorus	0.012

The Rex Carbon Coal Co., of Pittsburg, Pa., opened a mine in 1905 just south of the Wabash railroad, one mile west of the State line, and nearly opposite the mouth of Parmar run. The mine is 125 feet below the top of the hill. It employs 150 people, the daily capacity is 500 to 600 tons, and the mine is connected with railroad by a short switch. The structure of the vein at this mine is:

	Ft.	in.	Ft.	in.
Roof coal	0	10		
Draw slate or clay	0	10		
Breast coal	2	8		
Bands	0	3½	5	9½
Bottom coal	2	10		

On the outcrop the breast coal is 3 feet 2 inches and the bottom coal 2 feet 6 inches, with a total thickness of six feet. The coal is quite irregular in thickness and apparently dips from all directions toward the center of the mine. Further east the Pittsburg coal is opened in a small bank 40 feet higher than the Rex mine, and the coal is four feet thick with eight inches of over-clay and two inches of roof coal. The Rex mine appears to be a local depression of the main seam.

The chemical composition of the coal at this mine is shown by the following analyses of air dried samples:

Proximate.		Ultimate.	
Fixed carbon	59.64	Carbon	77.36
Volatile matter	33.40	Hydrogen	5.55
Moisture	2.45	Oxygen	10.74
Ash	4.51	Nitrogen	1.14
		Sulphur	0.70
Total	100.00	Ash	4.51
Sulphur	1.31		
Phosphorus	0.01	Total	100.00

Calorimeter, B. T. U. 13,999
Calculated, B. T. U. 13,890

One mile north of the Rex mine, near the forks of farm road and county road to west of Parmar run is the Seese mine, 275 feet above the level of Cross creek and employing one or two miners in the winter season.

The coal has the following structure:

	Ft.	in.	Ft.	in.
Roof coal	0	2½		
Draw slate	1	0		
Breast coal	2	6		
Bands	0	3	4	3
Bottom coal	1	6		

Its chemical composition in air dried samples is:

Proximate.		Ultimate.	
Fixed carbon	59.86	Carbon	76.36
Volatile matter	33.65	Hydrogen	5.55
Moisture	2.40	Oxygen	12.28
Ash	4.09	Nitrogen	1.27
		Sulphur	0.45
Total	100.00	Ash	4.09
Sulphur	0.74		
Phosphorus	0.005	Total	100.00

Calorimeter, B. T. U. 13,800

Calculated, B. T. U. 13,617

The Addison Barnes mine is on the Whitsett farm one-fourth mile north of the Wabash railroad, on the county road just east of Ebenezer run. The structure of the Pittsburg coal at this mine is similar to the Seese mine. Its chemical composition is given below:

Proximate.		Ultimate.	
Fixed carbon	57.67	Carbon	74.45
Volatile matter	33.75	Hydrogen	5.55
Moisture	2.55	Oxygen	11.71
Ash	6.03	Nitrogen	1.11
		Sulphur	1.15
Total	100.00	Ash	6.03
Sulphur	1.84		
Phosphorus	0.009	Total	100.00

Calorimeter, B. T. U. 13,434

Calculated, B. T. U. 13,411

Mr. John McKim operates a mine in the Pittsburg coal one-half mile east of the Ohio river near Fairy Glen, opposite the city of Steubenville. The coal shows the following structure:

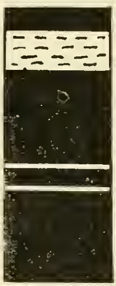
	Ft.	in.	Ft.	in.
Roof coal	0	4		
Draw slate	1	0		
Breast coal	2	4		
Bands	0	3	4	8
Bottom coal	2	1		

The coal is said to dip in all directions to the center of the mine, and the coal appears to be in a local depression similar to that of the Rex mine. The coal has the following chemical composition:

Proximate.		Ultimate.	
Fixed carbon	55.58	Carbon	75.91
Volatile matter	35.50	Hydrogen	5.22
Moisture	2.05	Oxygen	9.38
Ash	6.87	Nitrogen	1.07
		Sulphur	1.55
Total	100.00	Ash	6.87
Sulphur	2.48		
Phosphorus	0.01	Total	100.00

Calorimeter, B. T. U. 13,767
Calculated, B. T. U. 13,615

At the Lewis Mentor mine east of Wheeling Junction and one-half mile from the river, the structure of the coal is:



	Ft.	in.	Ft.	in.
Roof coal	0	4		
Draw slate	0	10		
Breast coal	1	11		
Bands	0	4	4	1
Bottom coal	1	10		

Fig. 14.—Coal structure at Mentor bank.

Its chemical composition is shown by the following analyses:

Proximate.		Ultimate.	
Fixed carbon	54.73	Carbon	73.64
Volatile matter	35.30	Hydrogen	5.11
Moisture	2.05	Oxygen	10.70
Ash	7.92	Nitrogen	1.08
		Sulphur	1.55
Total	100.00	Ash	7.92
Sulphur	2.46		
Phosphorus	0.03	Total	100.00

Calorimeter, B. T. U 13,318
Calculated, B. T. U 13,111

J. J. Swearingen has opened a mine on his farm just north of Brooke-Hancock county line, near the county road, one mile and a quarter east of Holliday's Cove. The structure of the coal at this mine was measured as follows:

	Ft.	in.	Ft.	in.
Roof coal	0	4		
Draw slate	1	0		
Breast coal	2	0		
Bands	0	3½	4	3½
Bottom coal	2	0		

Its chemical composition is as follows:

Proximate.		Ultimate.	
Fixed carbon	54.73	Carbon	75.82
Volatile matter	35.75	Hydrogen	5.00
Moisture	1.95	Oxygen	9.07
Ash	7.57	Nitrogen	1.19
		Sulphur	1.35
Total	100.00	Ash	7.57
Sulphur	2.18		
Phosphorus	0.05	Total	100.00

Calorimeter, B. T. U 13,418
Calculated, B. T. U 13,482

The P. T. Freshwater mine is located one mile north of Colliers town, just north of the little farm road to east from county road. The structure of the coal shows:

	Ft.	in.	Ft.
Roof coal	0	4	
Draw slate	1	0	
Breast coal	2	5	
Bands	0	4	4
Bottom coal	1	3	

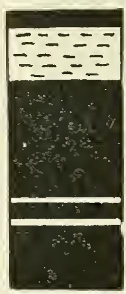


Fig. 15.—Coal structure at Freshwater bank.

The chemical composition of this coal is shown by the following analyses:

Proximate.		Ultimate.	
Fixed carbon	53.23	Carbon	72.82
Volatile matter	36.50	Hydrogen	4.67
Moisture	1.95	Oxygen	11.19
Ash	8.32	Nitrogen	1.00
		Sulphur	2.00
Total	100.00	Ash	8.32
Sulphur	3.22		
Phosphorus	0.01	Total	100.00

Calorimeter, B. T. U. 12,890
Calculated, B. T. U. 12,704

The Pittsburg Coal in Hancock County

The Pittsburg coal is found in a few high hills and ridges in the southern part of Hancock county, south of King's creek. The area of these outliers is small, but the coal has been opened in a number of small mines. It was sampled in two mines, one of which (Truax mine) is on the most northern outlier.

Mr. H. C. Campbell has opened this vein in a mine on his farm one mile north of Holliday's Cove and a half mile south of the road forks. The coal here shows the following structure:

	Ft.	in.	Ft.	in.
Roof coal	0	2		
Draw slate	1	0		
Breast coal	2	0		
Bands	0	3	4	3
Bottom coal	2	0		

Fig. 16.—Coal structure at Campbell bank.

Its chemical composition is:

Proximate.		Ultimate.	
Fixed carbon	55.74	Carbon	74.45
Volatile matter	34.35	Hydrogen	5.11
Moisture	2.25	Oxygen	9.91
Ash	7.66	Nitrogen	0.92
		Sulphur	1.95
Total	100.00	Ash	7.66
Sulphur	3.11		
Phosphorus	0.01	Total	100.00

Calorimeter, B. T. U.......................... 13,214
Calculated, B. T. U.......................... 13,126

The Don Truax mine on the Owen farm is on the extreme northern outlier of the Pittsburg coal, one mile and a quarter south of Kings creek at Osburn's mill and just east of road forks. The coal shows the following structure:

	Ft.	in.	Ft.	in.
Roof coal	0	3		
Draw slate	1	0		
Breast coal	2	6		
Bands	0	3½	4	7½
Bottom coal	1	10		

The following analyses show its chemical composition:

Proximate.		Ultimate.	
Fixed carbon	54.92	Carbon	73.64
Volatile matter	34.65	Hydrogen	5.00
Moisture	2.20	Oxygen	9.12
Ash	8.23	Nitrogen	1.21
		Sulphur	2.80
Total	100.00	Ash	8.23
Sulphur	4.49		
Phosphorus	0.005	Total	100.00

Calorimeter, B. T. U.......................... 13,144
Calculated, B. T. U.......................... 13,223

Average Composition of Pittsburg Coal.

The average composition of the Pittsburg coal from the mines in Brooke and southern Hancock counties is given below:

Proximate. (20 mines).		Ultimate. (16 mines).	
Fixed carbon	55.38	Carbon	73.66
Volatile matter	34.71	Hydrogen	5.09
Moisture	2.01	Oxygen	10.67
Ash	7.90	Nitrogen	1.08
		Sulphur	1.83
Total	100.00	Ash	7.67
Sulphur	3.05		
		Total	100.00

Fuel ratio..... 1.6 Carbon-hydrogen ratio...... 14.5
Calorimeter, B. T. U.......................... 13,286

The average composition of the Pittsburg coal from the entire area in the Pan Handle is as follows:

Proximate (33 mines).		Ultimate (22 mines).	
Fixed carbon	55.04	Carbon	73.36
Volatile matter	35.37	Hydrogen	5.30
Moisture	1.93	Oxygen	10.94
Ash	7.66	Nitrogen	1.07
		Sulphur	1.87
Total	100.00	Ash	7.46
Sulphur	3.17		
		Total	100.00

Fuel ratio---- 1.5 Carbon-hydrogen ratio---- 13.8
Calorimeter, B. T. U---------------------- 13,325

The average composition of Pittsburg coal in Fairmont region is given (Vol. II, p. 209) as:

Fixed carbon	54.64
Volatile matter	38.16
Moisture	0.75
Ash	6.45
Total	100.00
Sulphur	2.30

Fuel ratio---------------------------------- 1.4
Calorimeter, B. T. U---------------------- 14,125

The proximate analyses of the Pittsburg coal in the Pan Handle area show a higher percentage of ash and sulphur than in the Fairmont region, and the heating power as measured by the calorimeter is lower.

A comparison of the ultimate analyses shows a very uniform percentage of nitrogen, sulphur, and hydrogen. The oxygen and carbon vary within small limits. The carbon-hydrogen ratio has an average of 13.8 and reaches 15.7 in some samples.

In the work of the coal testing plant of the United States Geological Survey at St. Louis special attention was directed toward scientific classification of coals, and Mr. M. R. Campbell, after a study of the various components, came to the conclusion that the most satisfactory classification would be according to the carbon-hydrogen ratio as determined by the ultimate analyses.

Mr. Campbell states:[1] "The percentage of carbon forms the most satisfactory basis of classification so far tried, but carbon is only one of the important fuel elements of coal. Hydrogen is almost equally valuable, yet, as has been shown in a pre-

1. U. S. Geol. Survey, Profess. Paper. No. 48, part 1, p. 168.

vious table, this, taken alone, does not afford a satisfactory basis.

"The increase in the value of coal from the grade of brown lignite to that of anthracite involves both carbon and hydrogen; it depends upon an increase (or at least no diminution) in the amount of the former and a direct loss of the latter. For this reason the ideal classification should take account of both elements.

"Since the percentage of hydrogen decreases as the percentage of carbon increases, the two elements should not be combined by addition or by multiplication, for both of these processes would tend to equalize the results, and this is undesirable for purposes of classification. Subtraction or division, therefore, must be used to express the desired relation. The latter seems to be the most satisfactory."

Mr. Campbell in the report quoted above, proposes a classification of coals according to the carbon-hydrogen ratio. His grouping of the bituminous coals is as follows, though as yet no definite names are offered for the groups which are temporarily designated by letters:

	Carbon-hydrogen ratios.
Group F	20 to 17
Group G	17 to 14.4
Group H	14.4 to 12.5
Group I	12.5 to 11.2

Below the ratio 11.2 would come the lignite or brown coals of the later geological formations and peat.

The coals described in preceding paragraphs of this chapter, and those to be described from Hancock county, are given in the following table with their carbon-hydrogen ratios. The locations of the mines in this table are given under the description of the coal veins in this chapter:

Classification of the Coals of the Pan Handle Counties According to Carbon-Hydrogen Ratios.

Mine.	County.	Horizon.	Carbon-Hydrogen ratio.	B. T. U.
Group F. C—H ratio 20 to 17.				
Eagle	Hancock...	Clarion	19.4	12,949
Group G. C—H ratio 17 to 14.4.				
Erskine	Ohio.......	Waynesburg	15.1	12,689
Miller & Lyle....	"	"	14.5	12,593
Knight	"	Sewickley	14.9	13,241
Freshwater	Brooke	Pittsburg	15.6	12,890
Bethany College.	"	"	15.6	12,696
Barclay	"	"	15.5	12,698
Swearingen, J. J.	"	"	15.2	13,418
Hindman	"	"	15.0	12,408
Truax	Hancock ..	"	14.7	13,144
Campbell	" ..	"	14.6	13,214
McKim	Brooke	"	14.5	13,767
Brown	"	"	14.5	13,731
Mentor	"	"	14.4	13,318
Bell	"	"	14.4	13,243
Gubile & Beatty.	Hancock...	Brush Creek	16.5	13,305
Talbot	" ...	"	16.4	13,070
McCall	" ...	"	16.1	13,032
Swearingen	" ...	Mahoning	17.6	13,540
Harris	" ...	"	14.6	13,237
Watson	" ...	Lower Freeport.	15.5	13,760
Rocky Side.......	" ...	Lower Kittanning	15.6	14,373
Clifton	" ...	" "	15.5	12,612

Group H. C—H ratio 14.4 to 12.5.

Taggart	Ohio.......	Washington	12.8	10,179
Zane	"	Waynesburg	14.3	12,594
Phillabaum	"	"	14.3	12,623
Bope	"	"	12.9	12,773
Creighton	"	Sewickley	13.1	9,724
Cram	Brooke	Pittsburg	14.3	12,950
Rex	"	"	13.9	13,999
Seese	"	"	13.7	13,800
Barnes	"	"	13.4	13,434
Carmichael	"	"	13.3	13,567
Murray	Ohio.......	"	13.3	13,463
Beck	Brooke	"	13.2	13,593
Tolman	Ohio.......	"	12.9	13,537
Creighton	"	"	12.7	12,931
Shannon	"	"	12.7	13,604
Marquette No. 4.	Hancock...	Mahoning	14.2	14,009
Wern	" ...	"	13.2	13,439
Fulmer	" ...	Lower Freeport.	14.1	12,821
Allison	" ...	" " .	12.5	12,042
McNeill	" ...	Mid. Kittanning.	12.6	12,048
Claymont	" ...	Lower Kittanning	13.8	13,124

Group I. C—H ratio 12.5 to 11.2.

Stark	Ohio.......	Pittsburg	11.7	13,330
Hilton	"	"	11.4	13,729
Brice	Hancock...	Lower Freeport.	11.8	12,271

Slaty Coals.

Taggart slaty coal	Ohio.......	Washington	5.3	.....
Hinerman	"	Waynesburg	8.3	9,447

In the chemical work for the coal report of the state ultimate analyses were not made, but a few of the coals of the State have been tested at St. Louis, and the results are added for comparison with the Pan Handle veins. The following data are taken from the report of the U. S. Geological Survey testing plant at St. Louis:

Group F.

Mine.	County.	Horizon.	Carbon-Hydrogen ratio.	B. T. U.
Zenith	McDowell..	Pocahontas	19.6	15,786
Mora	Mercer.....	"	18.7	15,927
Rush Run.......	Fayette....	New River......	17.8	15,743

Group G.

Mine.	County.	Horizon.	Carbon-Hydrogen ratio.	B. T. U.
Bretz	Preston	Upper Freeport.	16.1	15,440
Coalton	Randolph ..	" " .	15.9	15,396
Richard	Monongalia	" " .	15.5	15,325
Pitcairn	Harrison ..	Pittsburg	14.4	15,048
Kingmont	Marion	"	14.9	14,164

When these results are compared with those obtained in the investigation of the Pan Handle coals the latter show lower calorific value as determined by calorimeter, but their carbon-hydrogen ratios agree closely, suggesting that the Pan Handle coals are of good quality, and are to be compared with the standard coals of the state in Group G.

CONEMAUGH AND ALLEGHENY COALS IN HANCOCK COUNTY.

Bakerstown Coal.

The Bakerstown coal was formerly mined near Colliers town in Brooke county, on the Pennsylvania railroad at the Blanche mine, and supplied the engines of the railroad for a number of years. The mine is now closed, but the chemical composition of the coal is shown by the following analysis taken from the Survey coal report (Vol. II, p. 267):

Fixed carbon..	52.36
Volatile matter......................................	41.25
Moisture	0.78
Ash	5.61
Total..	100.00
Sulphur	3.15
Phosphorus	0.0055

Brush Creek Coal.

About 200 to 210 feet below the Ames limestone, in the northern part of Hancock county, a coal is opened in a number of small mines. Its position appears to be that of the Brush creek horizon. The coal is 3 feet 3 inches thick at the John Talbot mine and is underlaid by fire clay, with a roof of fine sandy shales. This mine is 1057 feet above mean tide, and is

	Ft.	in.
Shales	8+	0
Coal	3	0
Fire clay	2+	

Fig. 17.—Coal structure at Talbot bank.

located up a small run, one mile and a quarter north of Tomlinson run, and three miles southeast of Congo. It supplies the farmers of this region with fuel, and 12 to 16 tons are mined daily through the winter season.

The coal has the following chemical composition:

Loss of moisture on air drying..........1.07 per cent.

Proximate.	
Fixed carbon	58.11
Volatile matter	32.00
Moisture	3.65
Ash	6.24
Total	100.00
Sulphur	2.36
Phosphorus	0.0028

Ultimate.	
Carbon	76.36
Hydrogen	4.66
Oxygen	10.15
Nitrogen	1.14
Sulphur	1.45
Ash	6.24
Total	100.00

Calorimeter, B. T. U..........................13,070

Calculated B. T. U..........................13,248

Analyses corrected to sample as received:

Proximate.		Ultimate.	
Fixed carbon	57.48	Carbon	75.54
Volatile matter	31.66	Hydrogen	1.78
Moisture	4.62	Oxygen	10.93
Ash	6.18	Nitrogen	1.13
		Sulphur	1.44
Total	100.00	Ash	6.18
Sulphur	2.34		
Phosphorus	0.0028	Total	100.00

Calorimeter, B. T. U.......................12,931
Calculated B. T. U.......................13,160

The Benjamin McCall mine is located up Mercer run one mile and a quarter north of the North Fork of Tomlinson run, and three miles southwest of Chester. The coal is 2 feet 6 inches thick with hard clay floor and a roof of fine shales. The horizon is about 200 feet below the Ames.

The following analyses show the chemical composition of the coal at the McCall mine:

Loss of moisture on air drying..........0.83 per cent.

Proximate.		Ultimate.	
Fixed carbon	58.65	Carbon	76.36
Volatile matter	28.98	Hydrogen	4.72
Moisture	5.72	Oxygen	10.00
Ash	6.65	Nitrogen	0.97
		Sulphur	1.30
Total	100.00	Ash	6.65
Sulphur	2.11		
Phosphorus	0.02	Total	100.00

Calorimeter, B. T. U.......................13,032
Calculated B. T. U.......................13,311

Analyses corrected to sample as received:

Proximate.		Ultimate.	
Fixed carbon	58.16	Carbon	75.73
Volatile matter	28.74	Hydrogen	4.81
Moisture	6.50	Oxygen	10.60
Ash	6.60	Nitrogen	0.97
		Sulphur	1.29
Total	100.00	Ash	6.60
Sulphur	2.09		
Phosphorus	0.02	Total	100.00

Calorimeter, B. T. U.......................12,924
Calculated B. T. U.......................13,230

A short distance north of the McCall mine, Gubile & Beatty operate a small mine in the same coal which reaches a thickness of 3 feet with clay below and shales above.

Its chemical composition is given below:

Loss of moisture on air drying.........0.42 per cent.

Proximate.		Ultimate.	
Fixed carbon	58.55	Carbon	77.18
Volatile matter	32.55	Hydrogen	4.69
Moisture	3.40	Oxygen	9.72
Ash	5.50	Nitrogen	1.11
		Sulphur	1.80
Total	100.00	Ash	5.50
Sulphur	2.89		
Phosphorus	0.01	Total	100.00

Calorimeter, B. T. U.........................13,305

Calculated B. T. U.........................13,449

Analyses corrected to sample as received:

Proximate.		Ultimate.	
Fixed carbon	58.30	Carbon	76.86
Volatile matter	32.41	Hydrogen	4.74
Moisture	3.81	Oxygen	10.01
Ash	5.48	Nitrogen	1.11
		Sulphur	1.80
Total	100.00	Ash	5.48
Sulphur	2.68		
Phosphorus	0.01	Total	100.00

Calorimeter, B. T. U.........................13,249

Calculated B. T. U.........................13,415

The Mahoning Coal.

The Mahoning coal is valuable at but few places in the Appalachian field. It is found in good development in the Ohio valley in Hancock county, West Virginia, and adjoining counties in Ohio. The coal in this area reaches good thickness but is often very irregular in dip and the sandstone roof dips down here and there, cutting out the coal wholly or in part.

The Mahoning coal near New Cumberland is mined in railroad mines by the Cleveland Coal Co., successors to the Marquette Coal Company. The coal is mined one mile southeast of Zalia, and it may be traced by the old abandoned mines along the river bluffs, two miles and a half north of New Cumberland, or a total length of six miles. It is mined again on Middle run

south of Chester, but the coal apparently does not extend over this entire area in workable thickness.

The structure of the coal at the old Marquette mine up Herron run, east of New Cumberland, was measured by A. P. Brady (Vol. II, p. 308):

				Ft.	in
Sandstone, Upper Mahoning.					
Slate				10	0
		Ft.	in.		
Coal, Mahoning	Coal	3	0	5	$2\frac{1}{4}$
	Sulphur	0	$\frac{1}{4}$		
	Coal	2	2		
Fire clay.					

The analysis of this coal shows the following composition (Vol. II, p. 308):

Fixed carbon	56.55
Volatile matter	36.38
Moisture	1.15
Ash	5.92
Total	100.00
Sulphur	1.45
Phosphorus	0.005

The Marquette No. 4 mine was opened to the east of the last mine about five months ago. The coal is 3 feet 6 inches to 4 feet thick with a roof of 5 inches of bony coal separated from

	Ft.	in.
Sandstone		
Shales	7	
Bony coal	0	5
Coal	4	0
Clay	3+	

Fig. 18.—Coal structure at Marquette mine No. 4.

the overlying sandstone by seven feet of shales. The composition of the coal is given by the following analyses:

Loss of moisture on air drying..........0.30 per cent.

Proximate.		Ultimate.	
Fixed carbon	62.25	Carbon	79.09
Volatile matter	30.69	Hydrogen	5.56
Moisture	2.94	Oxygen	8.63
Ash	4.12	Nitrogen	1.10
		Sulphur	1.50
Total	100.00	Ash	4.12
Sulphur	2.35		
Phosphorus	0.007	Total	100.00

Calorimeter, B. T. U..........14,009
Calculated B. T. U..........14,358

Analyses corrected to sample as received:

Proximate.		Ultimate.	
Fixed carbon	62.06	Carbon	78.85
Volatile matter	30.60	Hydrogen	5.59
Moisture	3.23	Oxygen	8.85
Ash	4.11	Nitrogen	1.10
		Sulphur	1.50
Total	100.00	Ash	4.11
Sulphur	2.35		
Phosphorus	0.007	Total	100.00

Calorimeter, B. T. U..........13,967
Calculated B. T. U..........14,308

The Gormer Wern mine in the Mahoning coal is a small mine opened for local supply, one-half mile east of the Marquette mines, and three-fourths mile north of Hardin run. The coal is 2 feet 8 inches thick, with three feet of fire clay floor exposed. It has the following composition:

Loss of moisture on air drying..........0.47 per cent.

Proximate.		Ultimate.	
Fixed carbon	60.01	Carbon	73.64
Volatile matter	31.85	Hydrogen	5.56
Moisture	2.80	Oxygen	12.98
Ash	5.34	Nitrogen	0.78
		Sulphur	1.70
Total	100.00	Ash	5.34
Sulphur	2.72		
Phosphorus	0.007	Total	100.00

Calorimeter, B. T. U..........13,439
Calculated B. T. U..........13,223

Analyses corrected to sample as received:

Proximate.		Ultimate.	
Fixed carbon	59.73	Carbon	73.29
Volatile matter	31.70	Hydrogen	5.61
Moisture	3.26	Oxygen	13.31
Ash	5.31	Nitrogen	0.78
		Sulphur	1.70
Total	100.00	Ash	5.31
Sulphur	2.71		
Phosphorus	0.007	Total	100.00

Calorimeter, B. T. U -------------------------- 13,376
Calculated B. T. U -------------------------- 13,179

The Mahoning coal has been worked for many years on the J. G. Swearingen farm, three-fourths of a mile southeast of Zalia, and one-half mile east of the river. In the mine recently opened on this farm the coal shows the following structure:

	Ft.	in.	Ft.	in.
Sandstone				
Shales	4+			
Coal	1	1		
Parting (often absent)	0	¼	3	3¼
Coal	2	2		
Clay	1+			

Fig. 19.—Coal structure at Swearingen bank.

The chemical composition of the coal is:

Loss of moisture on air drying ---------- 0.43 per cent.

Proximate.		Ultimate.	
Fixed carbon	55.44	Carbon	77.45
Volatile matter	34.51	Hydrogen	4.44
Moisture	2.89	Oxygen	7.57
Ash	7.16	Nitrogen	0.98
		Sulphur	2.40
Total	100.00	Ash	7.16
Sulphur	3.93		
Phosphorus	0.01	Total	100.00

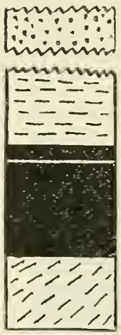
Calorimeter, B. T. U -------------------------- 13,540
Calculated B. T. U -------------------------- 13,525

Analyses corrected to sample as received.

Proximate.		Ultimate.	
Fixed carbon	55.20	Carbon	77.12
Volatile matter	34.36	Hydrogen	4.49
Moisture	3.31	Oxygen	7.89
Ash	7.13	Nitrogen	0.98
		Sulphur	2.39
Total	100.00	Ash	7.13
Sulphur	3.91		
Phosphorus	0.01	Total	100.00

Calorimeter, B. T. U. 13,482
Calculated B. T. U. 13,484

The Mahoning coal is mined by J. W. Harris one mile and a half up Middle run, south of Chester, where it shows the following structure:



	Ft.	in.	Ft.	in.
Sandstone				
Shales	15			
Coal	0	2		
Parting (often absent)	0	½	2	½
Coal	1	10		
Fire clay				

Fig. 20.—Coal structure at the Harris bank.

The coal at the Harris mine has the following chemical composition:

Loss of moisture on air drying .... 0.76 per cent.

Proximate.		Ultimate.	
Fixed carbon	58.77	Carbon	74.45
Volatile matter	30.15	Hydrogen	5.11
Moisture	5.20	Oxygen	12.01
Ash	5.88	Nitrogen	1.15
		Sulphur	1.40
Total	100.00	Ash	5.88
Sulphur	2.25		
Phosphorus	0.004	Total	100.00

Calorimeter, B. T. U. 13,237
Calculated B. T. U. 13,124

Analyses corrected to sample as received:

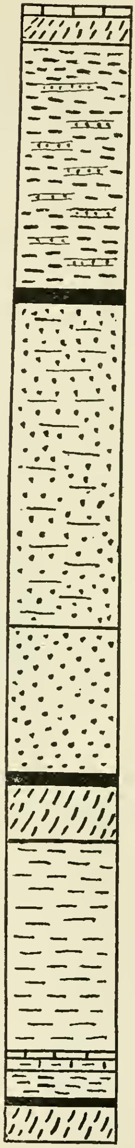
Proximate.		Ultimate.	
Fixed carbon	58.32	Carbon	73.89
Volatile matter	29.92	Hydrogen	5.19
Moisture	5.92	Oxygen	12.55
Ash	5.84	Nitrogen	1.14
		Sulphur	1.39
Total	100.00	Ash	5.84
Sulphur	2.23		
Phosphorus	0.004	Total	100.00

Calorimeter, B. T. U.....13,137
Calculated B. T. U.....13,046

A comparison of these four analyses of Mahoning coal shows the Marquette No. 4 coal to have the highest heating value as determined by the calorimeter and fuel ratio (2) and it is the highest in carbon (79.09) of any coal in the Pan Handle area.

The carbon-hydrogen ratio is highest in the coal from the Swearingen mine (17.6) which shows the lowest fuel ratio (1.6). The coals from the Wern and Harris mines agree closely in proximate and ultimate analyses, though they are five miles and a half apart. The sulphur percentage is lowest in Harris mine (2.25) and highest in the Swearingen mine (3.93).

The succession of the rock formations in the Allegheny Series is illustrated in the following diagram section of the strata north of New Cumberland, Hancock county:



	Ft.	in.
Upper Freeport coal horizon.		
Upper Freeport limestone.....	2	
Bolivar fire clay...............	8	
Shales and thin sandstones....	72	
Coal (Roger), Lower Freeport.	2	6
Shaly sandstone	90	
Sandstone	40	
Coal, Lower Kittanning........	2	
Clay, Lower Kittanning.......	15	
Buff shales..................	55	
Ferriferous limestone.........	0	6
Shaly limestone..............	2	3
Shales	7	
Clarion coal	0	4
Clarion clay	10	0

Fig. 21.—Section of the rocks north of New Cumberland.

The Lower Freeport Coal.

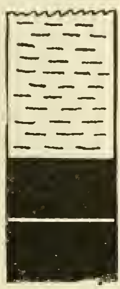
The Lower Freeport coal, locally known as the Roger vein and King's creek vein, was formerly mined along the river bluffs, 90 to 100 feet below the Mahoning coal and about 120 feet above the Lower Kittanning or "clay vein." At the present time there are no large mines opened in this vein, but it is worked in small banks at a number of places. The Lower Freeport coal, three miles and a half up King's creek, near Osburn's mill, was carefully examined a year ago by a Pittsburg company known as the Hancock Coal & Coke Company, which held under option some 23,000 acres of coal lands from the Ohio river east into Washington and Beaver counties, Pennsylvania. Through the courtesy of this company the following analyses of the coal on the Hudson farm, a quarter mile east of Osburn's mill, are presented.

According to their tests the coal yielded 14,681 cubic feet of gas to the ton of coal.

	Coal.	Coal.	Coke.
Fixed carbon	51.80	53.06	85.32
Volatile matter	38.38	40.46	2.83
Moisture	1.84	0.41	0.51
Ash	7.98	6.07	11.34
Total	100.00	100.00	100.00
Sulphur	1.09	0.94	0.74
Phosphorus	0.003	0.006	0.013

The coal dips N. 60 W. about 1¼ feet per 100 feet, according to the above report. It requires 1.66 tons of coal to make one ton of coke.

A little less than a half mile east of the river and three-fourths of a mile north of King's creek, or one-half mile south of Zalia, Mr. John Glazier has opened a small mine in the Lower Freeport coal on the Brice farm, where the following structure was measured:



	Ft.	in.	Ft.	in.
Shales, fine	20			
Coal	1	3		
Parting	0	¼	2	5¼
Coal	1	2		

Fig. 22.—Coal structure at Glazier bank.

This coal has the following chemical composition:

Loss of moisture on air drying----------0.73 per cent.

Proximate.		Ultimate.	
Fixed carbon	52.32	Carbon	66.82
Volatile matter	30.68	Hydrogen	5.67
Moisture	6.67	Oxygen	13.18
Ash	10.33	Nitrogen	0.90
		Sulphur	3.10
Total	100.00	Ash	10.33
Sulphur	4.94		
Phosphorus	0.008	Total	100.00

Calorimeter, B. T. U------------------------12,271

Calculated B. T. U-------------------------12,355

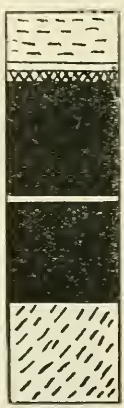
Analyses corrected to sample as received:

Proximate.		Ultimate.	
Fixed carbon	51.93	Carbon	66.33
Volatile matter	30.46	Hydrogen	5.75
Moisture	7.35	Oxygen	13.68
Ash	10.26	Nitrogen	0.90
		Sulphur	3.08
Total	100.00	Ash	10.26
Sulphur	4.91		
Phosphorus	0.008	Total	100.00

Calorimeter, B. T. U------------------------12,182

Calculated B. T. U-------------------------12,277

The J. A. Watson mine is located four miles north of New Cumberland on the road three-fourths of a mile north of Tomlinson run, and a half mile east of the Ohio river. The coal has the following structure:



	Ft.	in.	Ft.	in.
Shales	10			
Clay	0	2		
Bone coal	0	3		
Coal	2	4		
Slate	0	⅛	4	7⅛
Coal	2	0		
Fire clay	2+			

Fig. 23.—Coal structure at Watson bank.

Plate X.—Morgantown Sandstone Near Rockdale, Brooke County.

Its chemical composition is shown by the following analyses:

Loss of moisture on air drying..........0.63 per cent.

Proximate.		Ultimate.	
Fixed carbon	59.84	Carbon	76.64
Volatile matter	32.50	Hydrogen	4.94
Moisture	2.25	Oxygen	10.80
Ash	5.41	Nitrogen	1.06
		Sulphur	1.15
Total	100.00	Ash	5.41
Sulphur	1.83		
Phosphorus	0.007	Total	100.00

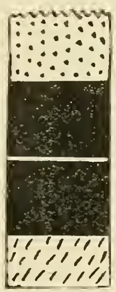
Calorimeter, B. T. U..........................13,760
Calculated B. T. U..........................13,419

Analyses corrected to sample as received:

Proximate.		Ultimate.	
Fixed carbon	59.45	Carbon	76.16
Volatile matter	32.30	Hydrogen	5.01
Moisture	2.87	Oxygen	11.26
Ash	5.38	Nitrogen	1.05
		Sulphur	1.14
Total	100.00	Ash	5.38
Sulphur	1.82		
Phosphorus	0.007	Total	100.00

Calorimeter, B. T. U..........................13,672
Calculated B. T. U..........................13,356

The Watt Allison mine is located one mile up Middle run, south of Chester, and has the following structure:



	Ft.	in.	Ft.	in
Sandstone				
Coal	1	6		
Parting	0	⅛	3	⅛
Coal	1	6		
Fire clay	1+			

Fig. 24.—Coal structure at Allison bank.

Its chemical composition is:

Loss of moisture on air drying ---------- 0.70 per cent.

Proximate.		Ultimate.	
Fixed carbon	51.92	Carbon	66.54
Volatile matter	31.37	Hydrogen	5.33
Moisture	7.30	Oxygen	15.78
Ash	9.41	Nitrogen	0.84
		Sulphur	2.10
Total	100.00	Ash	9.41
Sulphur	3.39		
Phosphorus	0.007	Total	100.00

Calorimeter, B. T. U ---------------------------- 12,042
Calculated B. T. U ---------------------------- 11,848

Analyses corrected to sample as received:

Proximate.		Ultimate.	
Fixed carbon	51.55	Carbon	66.08
Volatile matter	31.15	Hydrogen	5.41
Moisture	7.95	Oxygen	16.23
Ash	9.35	Nitrogen	0.84
		Sulphur	2.09
Total	100.00	Ash	9.35
Sulphur	3.37		
Phosphorus	0.007	Total	100.00

Calorimeter, B. T. U ---------------------------- 11,958
Calculated B. T. U ---------------------------- 11,792

One half mile north of the Allison mine is the S. O. Fulmer mine, with similar structure in the coal. Its chemical composition is shown by the following analyses:

Loss of moisture on air drying ---------- 0.42 per cent.

Proximate.		Ultimate.	
Fixed carbon	54.50	Carbon	70.64
Volatile matter	32.43	Hydrogen	5.00
Moisture	5.00	Oxygen	13.11
Ash	8.07	Nitrogen	0.93
		Sulphur	2.25
Total	100.00	Ash	8.07
Sulphur	3.59		
Phosphorus	0.007	Total	100.00

Calorimeter, B. T. U ---------------------------- 12,821
Calculated B. T. U ---------------------------- 12,449

Analyses corrected to sample as received:

Proximate.		Ultimate.	
Fixed carbon	54.26	Carbon	70.35
Volatile matter	32.30	Hydrogen	5.05
Moisture	5.40	Oxygen	13.39
Ash	8.04	Nitrogen	0.93
		Sulphur	2.24
Total	100.00	Ash	8.04
Sulphur	3.58		
Phosphorus	0.007	Total	100.00

Calorimeter, B. T. U. 12,767
Calculated B. T. U. 12,418

A comparison of the four complete analyses of the Lower Freeport coal in Hancock county shows that the coal from Watson mine ranks first in carbon-hydrogen ratio (15.5) calorific value, fuel ratio (1.8), and contains the most carbon, the least sulphur.

As the Lower Freeport coal is followed southward from Hancock county it passes under the river about two miles below the mouth of King's creek, and is mined in deep shafts at Steubenville, Mingo, Wellsburg, Rush Run. The chemical composition of the coal in the shaft mines on the Ohio side is given below:[1]

	Rush Run.	Mingo.	Steubenville.
Fixed carbon	62.20	58.60	65.90
Volatile matter	31.30	34.60	30.90
Moisture	1.90	2.00	1.40
Ash	4.60	4.80	1.80
Total	100.00	100.00	100.00
Sulphur	2.06	2.20	0.96

At Wellsburg, in Brooke county, the Lower Freeport coal was mined in the old shaft, 244 feet deep, but this has been abandoned since 1891. Mr. J. C. Cram has furnished the following analyses of this coal and coke made from it:

	Coal.	Coke.
Fixed carbon	65.90	90.63
Volatile matter	30.90	.....
Moisture	1.40	0.99
Ash	1.80	8.38
Total	100.00	100.00
Sulphur	0.98	0.27

1. Ohio Geol. Survey, vol. III, p. 779.

The Middle Kittanning Coal.

This coal occurs 20 to 30 feet above the Lower Kittanning coal, locally known as the "clay vein" near New Cumberland. It has been mined at a few places south of New Cumberland to below King's creek, also north to Congo. The coal ranges from one to four feet, reaching an unusual thickness of nearly seven feet on the outcrop at the old mine of the Congo Coal Co.

At the present time most of these mines have fallen in, but at the George McNeill mine on the river bank just below the mouth of King's creek, the following structure was measured:

	Ft.	in.	Ft.	in.
Heavy sandstone........	20			
Buff shales	2			
Bone coal................	0	7		
Coal	0	5		
Parting	0	$\frac{1}{8}$		
Coal	2	3	3	$3\frac{1}{8}$
Fire clay	2			

Fig. 25.—Coal structure at McNeill bank.

The chemical composition is shown by the following analyses:

Loss of moisture on air drying..........0.60 per cent.

Proximate.		Ultimate.	
Fixed carbon.............	51.72	Carbon	66.00
Volatile matter...........	30.43	Hydrogen	5.22
Moisture	5.90	Oxygen	12.24
Ash	11.95	Nitrogen	0.94
		Sulphur	3.65
Total	100.00	Ash	11.95
Sulphur	5.86		
Phosphorus	0.008	Total	100.00

Calorimeter, B. T. U..........................12,048

Calculated B. T. U............................12,017

Analyses corected to sample as received:

Proximate.		Ultimate.	
Fixed carbon	51.41	Carbon	65.61
Volatile matter	30.25	Hydrogen	5.29
Moisture	6.47	Oxygen	12.66
Ash	11.87	Nitrogen	0.94
		Sulphur	3.63
Total	100.00	Ash	11.87
Sulphur	5.83		
Phosphorus	0.008	Total	100.00

Calorimeter, B. T. U.......................11,976
Calculated B. T. U.......................11,989

Lower Kittanning Coal.

The Lower Kittanning coal, 2 to 3 feet in thicknes., is removed with the underlying fire clay in the New Cumberland mines, but the clay is far more valuable than the coal. The coal mined in this way is used at the brick plants under the boilers, but is said to be too low in heating value for use in the kilns.

At the Claymont plant of the Porter Brick Company, located one mile and a half south of New Cumberland on the bank of the Ohio river, the Lower Kittanning coal is 2 to 3 feet thick with sandstone roof and underlaid with 10 to 15 feet of fire clay mined for use at this plant.

The chemical composition of the coal at this place is shown by the following analyses:

Loss of moisture on air drying..........1.05 per cent.

Proximate.		Ultimate.	
Fixed carbon	51.81	Carbon	72.27
Volatile matter	36.63	Hydrogen	5.22
Moisture	4.22	Oxygen	12.08
Ash	7.34	Nitrogen	0.89
		Sulphur	2.20
Total	100.00	Ash	7.34
Sulphur	3.54		
Phosphorus	0.0056	Total	100.00

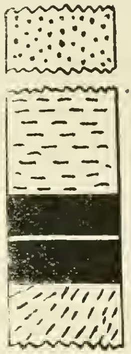
Calorimeter, B. T. U.......................13,124
Calculated B. T. U.......................12,902

Analyses corrected to sample as received:

Proximate.		Ultimate.	
Fixed carbon	51.26	Carbon	71.51
Volatile matter	36.25	Hydrogen	5.34
Moisture	5.23	Oxygen	12.83
Ash	7.26	Nitrogen	0.88
		Sulphur	2.18
Total	100.00	Ash	7.26
Sulphur	3.50		
Phosphorus	0.0056	Total	100.00

Calorimeter, B. T. U. 12,987
Calculated B. T. U. 12,809

At the Clifton mine of the Mack Manufacturing Company, one mile north of New Cumberland, the following structure was measured:



	Ft.	in.	Ft.	in.
Sandstone	20			
Shales	8			
Coal	0	9		
Pyrite parting	0	¼	1	6¼
Coal	0	9		
Fire clay	8+			

Fig. 26. Coal structure at Clifton mine.

In some parts of this mine the coal reaches 2 feet 6 inches, and in places it is nearly cut out by the roof shales. The chemical composition of the coal is:

Loss of moisture on air drying .... 0.22 per cent.

Proximate.		Ultimate.	
Fixed carbon	52.17	Carbon	72.27
Volatile matter	37.33	Hydrogen	5.00
Moisture	3.17	Oxygen	11.05
Ash	7.33	Nitrogen	1.05
		Sulphur	3.30
Total	100.00	Ash	7.33
Sulphur	5.28		
Phosphorus	0.0056	Total	100.00

Calorimeter, B. T. U. 12,612
Calculated B. T. U. 12,889

Analyses corrected to sample as received:

Proximate.		Ultimate.	
Fixed carbon	52.05	Carbon	72.11
Volatile matter	37.25	Hydrogen	5.02
Moisture	3.39	Oxygen	11.21
Ash	7.31	Nitrogen	1.05
		Sulphur	3.30
Total	100.00	Ash	7.33
Sulphur	5.27		
Phosphorus	0.0056	Total	100.00

Calorimeter, B. T. U 12,584

Calculated B. T. U 12,866

One mile further north is the Rocky Side No. 1 mine of the same company, where the coal has the following structure:

	Ft.	in.	Ft.	in.
Sandstone				
Coal	1		2	¼
Parting	0	¼		
Coal	1	0		
Fire clay	8 to 18 feet.			

Fig. 27. Coal structure at Rocky Side mine No. 1.

The chemical composition of the coal at this mine is:

Loss of moisture on air drying 0.21 per cent.

Proximate.		Ultimate.	
Fixed carbon	55.02	Carbon	78.28
Volatile matter	39.77	Hydrogen	5.00
Moisture	1.37	Oxygen	10.50
Ash	3.48	Nitrogen	1.07
		Sulphur	1.67
Total	100.00	Ash	3.48
Sulphur	2.67		
Phosphorus	0.007	Total	100.00

Calorimeter, B. T. U 14,343

Calculated B. T. U 13,717

Analyses corrected to sample as received:

Proximate.		Ultimate.	
Fixed carbon	54.89	Carbon	78.12
Volatile matter	39.69	Hydrogen	5.02
Moisture	1.94	Oxygen	10.64
Ash	3.48	Nitrogen	1.07
		Sulphur	1.67
Total	100.00	Ash	3.48
Sulphur	2.67		
Phosphorus	0.007	Total	100.00

Calorimeter, B. T. U. 14,343
Calculated B. T. U. 13,717

The three analyses of the Lower Kittanning coal in the New Cumberland region show a marked uniformity in composition, though the Rocky Side coal has the highest percentage of carbon and lowest sulphur, with the highest calorific value (14,373 B. T. U.) of any coal tested in the Pan Handle area, comparing favorably with the Pittsburg coal in the Fairmont area.

The fuel ratio in the three coals is 1.4, and the carbon-hydrogen ratio is nearly the same at the Clifton and Rocky Side mines. The chemical composition and fuel values of this vein of coal as given above are equal to the Pittsburg coal further south, which is now used in the brick kilns. These results do not indicate a low heating value for this vein of coal, as claimed to be the case in actual trials.

The Clarion Coal.

The Clarion coal in the New Cumberland area is only 3 to 8 inches thick, and is therefore of no economic importance. The underlying fire clay reaches 16 feet in thickness and is regarded as especially adapted to the manufacture of sewer pipe.

The coal on analysis is found to have a very high carbon-hydrogen ratio (19.4) the highest of the Pan Handle coals, and this ratio compares with the best bituminous coals of the country, but the heating value, as determined by the calorimeter, is not as high as many other coals in this area.

The following analyses represent the composition of this coal at the Eagle plant of the Mack Manufacturing Company, one mile and a half north of New Cumberland on the Ohio river bank.

ANALYSES OF COALS IN THE PAN HANDLE COUNTIES.

(All samples air dried, before analysis.)

					PROXIMATE.						ULTIMATE.					
Series	Lab. No.	MINE	COUNTY	HORIZON	Fixed Carbon	Volatile Matter	Moisture	Ash.	Sulphur	Phosphorus	Carbon	Hydrogen	Oxygen	Nitrogen	Sulphur	British Thermal Units by Calorimeter
Dunkard.	306	Taggart	Ohio	Washington	43.10	28.40	2.50	26.00	10.05	.018	54.00	4.22	8.61	0.87	6.30	10,179
Monongahela.	304	Zane	Ohio	Waynesburg	51.31	34.00	1.80	12.89	2.66	.005	70.91	4.94	8.51	1.10	1.65	12,594
	303	Philabaum ..	"	"	55.25	31.00	2.00	11.75	2.70	.003	70.91	4.93	9.75	0.96	1.70	12,623
		Triadelphia ..	"	"	51.39	36.60	1.90	10.11	6.23	.013	70.36	5.11	9.52	1.00	3.90	13,281
	302	Miller & Lyle	"	"	55.25	30.70	2.20	11.85	2.58	.003	72.00	4.95	8.50	1.10	1.60	12,593
	301	Bope	"	"	54.94	33.35	2.10	9.61	2.20	.003	70.36	5.44	11.94	1.25	1.40	12,773
	307	Erskine	"	"	51.23	34.85	2.00	11.92	2.03	.008	70.91	4.69	10.17	1.08	1.25	12,689
	312	Hinerman ...	"	"	39.34	26.30	2.70	31.66	2.70	.025	16.37	5.55	13.84	0.88	1.70	9,477
	300	Knight	"	Sewickley	53.06	36.08	1.70	9.16	2.45	.006	73.64	5.00	9.67	1.00	1.53	13,211
	311	Creighton ...	"	"	42.22	27.20	1.70	28.88	4.43	.006	53.27	4.06	10.11	0.93	2.75	9,721
	310	Creighton ...	"	Pittsburg	52.63	36.00	1.90	9.47	4.42	.....	70.77	5.55	10.43	1.03	2.75	12,931
	309	Stark	"	"	54.31	36.80	2.20	6.69	4.23	.006	71.73	6.11	12.73	1.09	1.65	13,330
	308	Hilton	"	"	54.58	37.20	2.30	5.92	3.01	.010	72.68	6.39	12.17	0.94	1.90	13,729
	315	Tolman	"	"	55.68	36.25	1.30	6.77	3.36	.003	73.09	5.67	11.32	1.05	2.10	13,537
	316	Shannon	"	"	58.69	33.30	2.15	5.86	3.05	.006	73.36	5.78	12.02	1.08	1.90	13,604
	314	Murray	"	"	55.16	36.00	2.15	6.69	2.70	.003	73.64	5.55	11.37	1.05	1.70	13,163
	320	Barclay	Brooke	"	54.18	31.78	2.12	11.92	4.13	.011	70.91	4.56	9.05	1.01	2.55	12,698
	321	Bell	"	"	51.48	36.42	2.03	9.07	4.38	.001	72.00	5.00	10.12	1.06	2.75	13,243
	322	Bethany Col..	"	"	57.98	33.91	1.89	6.22	2.99	.003	73.19	4.67	12.91	1.13	1.85	12,696
	319	Beck	"	"	58.63	32.85	2.45	6.07	3.23	.006	73.64	5.55	11.69	1.05	2.00	13,593
	318	Carmichael ..	"	"	57.83	33.45	2.25	6.47	4.01	.006	72.55	5.41	11.96	1.08	2.50	13,567
	317	Hindman	"	"	54.79	30.35	2.70	12.16	2.87	.011	70.36	4.67	10.00	1.01	1.80	12,408
	313	Cram	"	"	54.56	33.25	2.85	9.34	2.20	.007	71.45	5.00	11.81	1.00	1.10	12,950
	322	Brown	"	"	56.32	37.20	1.70	4.78	2.34	.008	77.36	5.33	9.78	1.00	1.45	13,731
	323	Rex	"	"	59.64	33.40	2.45	4.51	1.13	.019	77.36	5.55	10.74	1.14	0.70	13,999
	324	Seese	"	"	59.86	33.65	2.40	4.09	0.74	.005	76.36	5.55	12.28	1.27	0.45	13,800
	325	Barnes	"	"	57.67	33.75	2.55	6.03	1.84	.009	74.45	5.55	11.71	1.11	1.15	13,134
	331	McKim	"	"	55.58	35.50	2.05	6.87	2.48	.011	75.91	5.22	9.38	1.07	1.55	13,767
	330	Mentor	"	"	54.73	35.30	2.05	7.92	2.46	.030	73.64	5.11	10.70	1.08	1.55	13,318
	329	Swearingen .	"	"	54.73	35.75	1.95	7.57	2.18	.05	75.82	5.00	9.07	1.19	1.35	13,118
	328	Freshwater ..	"	"	53.23	36.50	1.95	8.32	3.22	.01	72.82	4.67	11.19	1.00	2.00	12,890
	326	Campbell ...	Hancock	"	55.74	34.35	2.25	7.66	3.11	.01	74.45	5.11	9.91	0.92	1.95	13,214
	327	Truax	"	"	54.92	34.65	2.20	8.23	4.49	.005	73.64	5.06	9.12	1.21	2.80	13,114
Conemaugh.	334	Gubile, Beatty	"	Brush Creek.....	58.55	32.55	3.40	5.50	2.89	.01	77.18	4.69	9.72	1.11	1.80	13,305
	335	McCall	"	"	58.65	28.98	5.72	6.65	2.11	.02	76.36	4.72	10.00	0.97	1.30	13,032
	348	Talbott	"	"	58.11	32.00	3.65	6.24	2.36	.003	76.36	4.66	10.15	1.14	1.45	13,070
	338	Marquette ...	"	Mahoning	62.25	30.69	2.94	4.12	2.35	.007	79.09	5.56	8.63	1.10	1.50	14,009
	333	Wern	"	"	60.01	31.85	2.80	5.34	2.72	.007	73.64	5.56	12.98	0.78	1.70	13,139
	342	Swearingen .	"	"	55.44	34.51	2.89	7.16	3.93	.01	77.45	4.41	7.57	0.98	2.40	13,510
	344	Harris	"	"	58.77	30.15	5.20	5.88	2.25	.004	74.45	5.11	12.01	1.15	1.40	13,237
Allegheny.	341	Brice	"	L. Freeport......	52.32	30.68	6.67	10.33	4.94	.008	66.82	5.67	13.18	0.90	3.10	12,271
	347	Watson	"	"	59.84	32.50	2.25	5.41	1.83	.007	76.64	4.94	10.80	1.06	1.15	13,760
	345	Allison	"	"	51.92	31.37	7.30	9.11	3.39	.007	66.54	5.33	15.78	0.84	2.10	12,042
	316	Fulmer	"	"	54.50	32.43	5.00	8.07	3.59	.007	76.64	5.06	13.11	0.93	2.25	12,821
	343	McNeill	"	M. Kittanning ...	51.72	30.43	5.90	11.95	5.86	.008	66.00	5.22	12.21	0.94	3.65	12,048
	340	Claymont ...	"	L. Kittanning.. .	51.81	36.63	4.22	7.34	3.54	.006	72.27	5.22	12.08	0.89	2.20	13,124
	337	Clifton	"	"	52.17	37.33	3.17	7.33	5.28	.006	72.27	5.00	11.05	1.05	3.30	12,612
	339	Rocky Side..	"	"	55.02	39.77	1.73	3.48	2.67	.007	78.28	5.00	10.50	1.07	1.67	14,373
	336	Eagle	"	Clarion	47.77	38.09	1.51	12.63	1.14	.086	75.55	3.89	7.07	1.16	0.70	12,919

Loss of moisture on air drying..........0.24 per cent.

Proximate.		Ultimate.	
Fixed carbon	47.77	Carbon	75.55
Volatile matter	38.09	Hydrogen	3.89
Moisture	1.51	Oxygen	7.07
Ash	12.63	Nitrogen	1.16
		Sulphur	0.70
Total	100.00	Ash	12.63
Sulphur	1.14		
Phosphorus	0.086	Total	100.00

Calorimeter, B. T. U..........................12,949

Calculated B. T. U..........................12,884

Analyses corrected to sample as received:

Proximate.		Ultimate.	
Fixed carbon	47.65	Carbon	75.36
Volatile matter	38.00	Hydrogen	3.92
Moisture	1.75	Oxygen	7.26
Ash	12.60	Nitrogen	1.16
		Sulphur	1.70
Total	100.00	Ash	12.60
Sulphur	1.14		
Phosphorus	0.086	Total	100.00

Calorimeter, B. T. U..........................12,918

Calculated B. T. U..........................18,861

CHAPTER VIII.

THE COALS OF THE STEUBENVILLE QUADRANGLE IN WEST VIRGINIA.[1]

(Brooke and Hancock Counties in part, from Buffalo Creek north to New Cumberland).

By W. T. Griswold, Geologist, United States Geological Survey.

LOCATION.

The area of the Steubenville quadrangle is within that favored portion of the United States which holds the world's record for actual value of production from the average acre of land. The surface, enriched by the disintegrated Benwood and Pittsburg limestones, has given a large yield of forest wealth, long ago removed over most of the area. The oval hills are today in a high state of cultivation, producing bountiful crops, while below the surface are coal beds of great value which will yield a full supply for future generations. The Pittsburg and Mahoning sandstones furnish valuable building material, and the Kittanning fire clay is the basis of a large sewer pipe and brick industry along the Ohio. Last, but not least, the porous sandstones far below the surface are the reservoirs of rich accumulations of petroleum and natural gas.

The value of an article depends upon its value at the point of consumption less the cost of transportation from the place of production to that of consumption. In order to place a true valuation on the resources of an area some knowledge of the existing lines of transportation is essential, as well as information concerning the conditions which will permit of future construction of

1. Published by permission of the Director U. S. Geological Survey. The portion of Mr. Griswold's original paper relating to Ohio and Pennsylvania has been omitted.—G. P. G.

new lines. The Steubenville quadrangle is well favored in these conditions. The Ohio river bisects the quadrangle from north to south, while two great railroad systems, the Pennsylvania and Wabash, cross the area from east to west.

The only unoccupied and feasible railroad route from east to west across the quadrangle is by way of King's creek, in West Virginia, and Island creek, in Ohio. The valley of Aunt Clara fork and King's creek offer good ground for railroad construction from the limits of the Burgettstown quadrangle to the point where King's creek turns to the north about 1¼ miles before entering the river, where a tunnel less than a half mile long would bring the road to the Ohio river opposite Brown's Island, and about sixty feet above the water. In Ohio, Island creek would give a favorable route westward to the summit on the western border of the quadrangle. From this point a ridge location would be followed to the western side of the Cadiz quadrangle, where the headwaters of the streams flowing southward through central Ohio are encountered. The proposed route east from the Steubenville quadrangle has been described in Bulletin 260 of the U. S. Geological Survey, page 406.

COALS OF THE AREA.

On account of the stratigraphic position of the Steubenville quadrangle nearly all the coal seams of the Carboniferous age from the Washington coal of the Dunkard series to the Lower Kittanning of the Allegheny, are represented in one place or another in the quadrangle.

From an economic standpoint only three or four seams are of much commercial value, and of these the Pittsburg coal is by far the most valuable. Most of the coal veins in this area only deserve mention by name with a statement of the cause of their low value.

Washington Coal. This coal is found only in a small area in the southeastern corner of the quadrangle. Its thickness varies from 3 to 4 feet. Further east the upper part of this seam is divided by slate partings, and the same condition probably exists in this area, so that the vein is of little or no commercial value.

Waynesburg Coal. The high hills in the southern third of the quadrangle carry the Waynesburg coal. The thickness is

from two to three feet, and the quality poor, as it carries a large amount of ash and slacks quickly. From a commercial standpoint this coal has but little value.

Meigs Creek Coal.[1] This seam is present in three-quarters of the quadrangle. In the southeast quarter the vein is represented by a black bituminous shale but little over a foot in thickness. In passing to the west the quality and thickness of the seam improves. Near the western side of the quadrangle (in Ohio) the coal has gained a thickness of two feet, and would be of commercial value if it was not for the proximity of the larger seams.

Pittsburg Coal. In the western portion of Pennsylvania, through the Pan Handle of West Virginia, and in Ohio, the Pittsburg coal is a seam 4 to 6 feet thick. The coal of this area is often described as the "Thin Pittsburg Coal," not on account of its especially thin character, but in distinction from the greater thickness of the seam along the Monongahela river and in the Connellsville basin, where the coal is 7 to 9 feet in thickness.

These measurements of size of the vein do not represent the full height of the seam, but only of that portion which is free enough from clay and shale to be economically mined at the present price of coal, and it represents the thickness upon which the operator bases his calculations of returns. Above the main body of commercial coal is a few inches to eight feet of coal composed of coal layers, a few inches to one foot each, separated by streaks of clay and shale, the whole forming the roof division of the coal.

The Pittsburg coal is remarkable for the persistence of its structure markings. The coal is divided into different benches in a similar manner throughout the greater portion of its area. These were well described by Dr. John J. Stevenson in volume K (p. 70) of the Second Geological Survey of Pennsylvania. The coal is divided into a roof division, upper bench, bearing-in, brick, and lower bottom benches.

METHOD OF DISCUSSION.

Within the Steubenville quadrangle the Pittsburg coal is discussed in areas determined by the topographic features and

1. This coal is called Sewickley in the other chapters of this report.—G. P. G.

the slope or dip of the coal. A section of the country between main drainage lines is selected and considered first, as to the quality and thickness of the seams; second the area is divided into smaller tracts which will be called mining areas. The factors used in dividing the section into mining areas are, economy of mining from some particular opening, the drainage of the mines, and the expense of road construction upon the surface to connect the mine with the main lines of transportation.

These mining areas are arbitrary divisions made by the writer, and in no way are intended to represent the only way in which the coal can be mined, neither do they assume in all cases that they are the best methods, but they define one of the practical ways in which the coal may be removed. The acreage and gross tonnage of the coal within each of these areas are given. When considered necessary, a few suggestions are given for the construction of surface railroads. It is hoped that by this method there will be presented all the essential facts necessary for a preliminary computation of the probable cost of the coal in a particular district when delivered to the main railroad lines or to the Ohio river.

COAL ANALYSES AND MINING AREAS.

Samples of coal were taken from a number of mines and analyzed under the supervision of Prof. J. A. Holmes at the U. S. Geological Survey coal testing plant at St. Louis, Mo. In taking the samples care was observed to enter the mine far enough to obtain coal whose moisture had not been affected by the outside atmosphere. A cut three inches wide by two inches thick was made from the top of the seam to the bottoom through all the workable benches, the partings being taken with the coal. The sample was caught upon a rubber blanket, upon which it was afterward broken into small pieces, thoroughly mixed and quartered down, a quart being placed in an air tight can and shipped for analysis.

Sulphur in the Pittsburg seam occurs in balls and streaks of iron pyrites. The result of a single sample taken from a mine will not give a true average of the sulphur contained in the entire seam in the mine, so much depending on a chance of cutting through a sulphur ball in securing the sample.

In the computation of coal tonnage, the area is obtained by measuring the space within the outcrop lines on the topographic map. The average thickness is computed from the different sections examined within or close to the area, and no allowance is made for coal already mined. The weight of the Pittsburg coal is taken as 80 pounds per cubic foot, and a ton of 2000 pounds would be equivalent to 25 cubic feet. These figures are obtained from averages of the specific gravities of the Pittsburg coal tested at the U. S. Geological Survey coal testing plant at St. Louis.

PITTSBURG COAL SOUTH OF BUFFALO CREEK.

This area contains 261 acres and 2,233,400 tons of coal. It is located south of Buffalo creek and the Ohio river, and between the two streams.[1] The coal was not examined, but it was assumed to have the same thickness as to the north and east. The area is now worked by one commercial mine which delivers the coal by an incline to the Pennsylvania railroad. The coal dips to the southeast and it could probably be mined more advantageously from some point farther south and delivered on Buffalo creek or the Ohio river. The area should be discussed in connection with the coal territory of the Wheeling quadrangle which joins the Steubenville on the south.

This area contains the greatest thickness of the Pittsburg seam found in the Steubenville quadrangle. The coal was measured in eight different places. The country bank of Frank Jacobs, operated by J. C. Cram just east of Wellsburg, shows a total thickness of 60 inches. The lower bench is 16 inches; the brick bench, 14 inches; the bearing-in bench, 4 inches; and the upper bench, 26 inches, which is divided by two very small breaks.

Sections measured at the local banks upon the farms of George Wilson and Kelley Park show similar structure to the Jacobs mine, though the upper bench in the Wilson mine is 5 inches less in height, and in both the seams dividing the bearing-in bench are unusually large. The Gilchrist mine, two miles north of Wellsburg, shows 65 inches of coal. The lower bench is unusually thick, 22 inches, with a 2-inch band of fire clay at the

1. This area would correspond, on geological map of Brooke county accompanying this report, to the Pittsburg coal north of a line drawn from a point one-fourth mile north of Greens run west to the river and within the boundaries given above.—G. P. G.

top. This increase in the lower bench is at the expense of the brick coal, as the bearing-in seam is of normal height from the bottom of the coal. The upper bench is exceptionally thick, 29 inches, divided by three small breaks. Further back in the mine the coal is said to become thinner, probably decreasing to 60 inches.

The section at the Rex mine on the steep hillside above Cross creek, opposite the mouth of Parmar run, deserves especial notice. The top of the coal has an elevation of 953 feet above mean tide, and the Ames limestone at the mouth of Parmar run has an elevation of 775 feet. Assuming a dip of 15 feet in the limestone to where it would be directly under the Pittsburg coal at the mine, the coal would be only 193 feet above the Ames limestone. This is 35 feet less than the average interval between these strata. At this mine the bottom bench is 20 inches, the bearing-in seams are 6 inches higher than normal, and the total height is 79 inches, or about 20 inches more than normal. The reduced interval between the Ames and the Pittsburg coal, together with the extreme thickness of the coal may indicate a local sag in the coal swamp which caused a longer period of coal deposition at this point.

The section of the mine further east near the Pennsylvania line shows the coal to be normal, and the roof division extends to the Pittsburg sandstone. The coal has a normal thickness in the mine of T. M. Ward, about one mile east of the state line in Pennsylvania, and three-fourths of a mile south of Cross creek. From this bank a sample was taken which gave the following results by analysis:

Moisture	4.50
Volatile matter	34.68
Fixed carbon	52.28
Ash	8.54
Sulphur	3.86

Of eight mines examined, only one showed less than 59 inches in thickness, so this figure was used in computing the gross tonnage of this area. As described in a preceding paragraph, the territory is further divided into mining areas.

Mining Area, B-1. This area contains 2,115 acres and 18,115,000 tons of coal. It lies between Cross creek, Potrock run, Painter's run, and the Ohio river. The coal is nearly level.

there being only a difference of about 30 feet between the highest and lowest points.

The coal reaches the highest level at the southwest, and the lowest point, on the outcrop between Potrock and Painters' runs. This block of coal could be mined to good advantage from both of these runs. The best location for development on Painter's run is probably at the forks of the run, three-fourths of a mile north of the Wellsburg and Fowlersville pike. A branch railroad extended from Buffalo creek up Painter's run two miles and a half to this point could receive the coal from the north and west by short inclines. The coal would thus be mined with the advantage of a down-hill haul, and the mines would drain to the mouths of the entries.

If the coal is to be removed by way of Potrock run, the mine entry should be located near the coal outcrop on that run, and the coal taken out by a main drift to the westward. This development would require the construction of a railroad up Potrock run from a connection with the Wabash railroad on Cross creek. Such a branch line would be one mile and a half long with 200 feet of grade in this distance.

Mining Area, B-2. This area contains 461 acres and 3,954,000 tons of coal. It includes the land between Potrock run and the next run to the east. It is in this area that the sag in the coal at the Rex mine is found. The coal could be readily mined to the east and delivered to a railroad up Potrock run.

Mining Area, B-3. This area contains 254 acres and 2,176,000 tons of coal, which dips to the south. It extends from the run on the eastern side of the last area to just beyond the state line, and it could be added to the area of B-5 or the coal could be delivered through drifts opening on Potrock run.

By adding the tonnage of areas B-2 and B-3 to that of B-1 a total of 24,245,000 tons could be mined and credited against the expense of a branch railroad up Potrock run.

Mining Area, B-4. This area contains 681 acres and 5,832,000 tons of coal. It is situated on the ridge between Painter's and Titt runs, with the coal dipping southeast.

This area has been opened by a commercial mine located at the south end of the ridge, which will deliver the coal by an incline to a railroad on Buffalo creek. At the time of the survey this mine was not yet in operation.

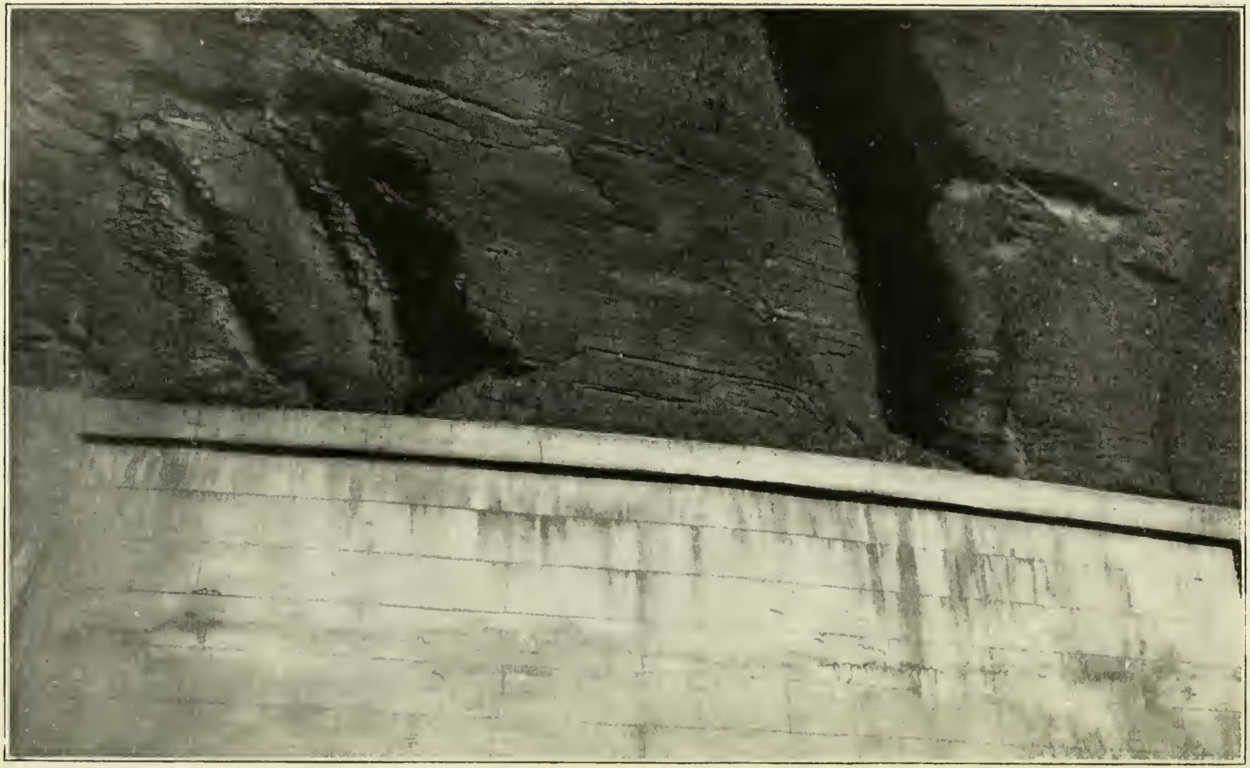


Plate XI.—Pittsburg Red Shales and Retaining Wall at Middle Ferry, Brooke County.

Mining Area, B-5. This area contains 4600 acres and 39,-390,000 tons of coal. It includes all the coal of the southeastern corner of the quadrangle, extending north to a line drawn one-fourth to a half mile north of and nearly parallel to the Wellsburg and Fowlersville pike, and west to Titt run and the head of Painter's run.

The outcrop on Pierce run presents a very favorable point for the development of this large body. A small area directly east of the outcrop on Pierce run may be found too low to drain itself, but the remaining portion is in excellent position for mining from this location. Whatever portion is too low for good drainage can be drained by a dolly drift opening further down Pierce run. Such a development of this large coal area would require three miles and a half of railroad down Pierce run to a connection with the railroad now built on Buffalo creek.

PITTSBURG COAL BETWEEN CROSS CREEK AND HARMON RUN

The territory between Cross creek and Harmon run has been eroded by Scott, Parmar, Ebenezer and Bosley runs, which enter Cross creek from the north. The Pittsburg coal has been left only upon the ridges between these runs and along the main ridge south of Harmon creek. The coal in this area has a strong dip to the south. The highest point of the anticlinal nose is between Parmar and Ebenezer runs. To the east of Parmar run the coal dips southeast, and west of Ebenezer run it dips southwest. Further north, at the head of McMahan run, the dip is west, and at the head of the north fork of this run the dip is south.

In Pennsylvania, just over the line near the head of Parmar run, is a small mine on the farm of Mrs. Mary Patterson. In this opening the coal has a thickness of 53 inches, the lower bearing-in slate is only 20 inches from the bottom of the bed. A sample was taken from the mine, which gave the following result upon analysis:

Loss of moisture on air drying	2.90
Moisture	4.73
Volatile matter	36.43
Fixed carbon	51.12
Ash	7.72
Sulphur	2.84

At the country bank on the farm of R. P. Pool, one mile and a half southwest of Colliers town, the workable coal is 55 inches in thickness. A sample from this mine gave the following result:

Loss of moisture on air drying	2.80
Moisture	5.06
Volatile matter	33.02
Fixed carbon	50.48
Ash	11.44
Sulphur	2.74

The tonnage in the mining areas of this district are computed with a thickness of 55 inches, which is probably small for the first two mining areas. As area D-1 is in Pennsylvania, it is here omitted.

Mining Area, D-2. This area contains 1502 acres and 12,005,000 tons of coal. It includes the coal lands upon the two ridges between Parmar and Ebenezer runs, and the coal has a decided dip to the south. It should be mined in that direction and delivered to the Wabash railroad by inclines at the south end of the ridges.

Mining Area, D-3. This division includes the coal area between Ebenezer and Bosley runs. It contains 761 acres and 6,076,000 tons of coal. The coal may best be mined from the southwest end of the ridge and delivered to the Wabash railroad by an incline and short spur railroad up Bosley run.

Mining Area, D-4. This area lies between the heads of Bosley and McMahan runs. It contains 541 acres and 5,444,000 tons of coal. The dip of the coal is heavy to the southwest, and it must be drained in that direction. The coal can be delivered to the Pennsylvania railroad by an incline and short switch up McMahan run.

Mining Area, D-.5 This area is north of McMahan run and east of the Ohio river. It contains 648 acres and 5,162,000 tons of coal. The coal of the south half has a strong dip to the south, while the northern portion dips south and east. The most economical development would be by an incline to a short railroad up McMahan run.

Mining Area, D-6. This area is south of Harmon run and between the run back of Colliers town and the run to the southeast of Holliday's Cove. It contains 1337 acres and 10,680,000 tons of coal. The area has been opened back of Colliers and connected

with the railroad by a tramway and incline to the mine. This development places the mouth of the mine in a favorable position to work the greater portion of the coal with the advantage of the dip. A portion of the coal to the south and west must be hauled up grade, but it can be drained by a dolly drift to the southwest. The mining areas D-4 and D-5 will probably deliver a large portion of their coal through this direction by hauling the coal up grade, and draining the mines to the southwest.

Mining Area, D-7. This small area just southwest of Holliday's Cove will probably be mined for local consumption. It contains 65 acres and 517,000 tons of coal.

Mining Area, D-8. This area is south and southwest of Colliers station, and the coal can be delivered to the Pennsylvania railroad by inclines. It contains 73 acres and 586,000 tons of coal.

PITTSBURG COAL NORTH OF HARMON CREEK.

North of Harmon creek the elevation of the Pittsburg coal is such that but small areas of the land are underlaid by this seam. These areas are in detached bodies along the tops of the ridges. They are for the most part at such distances from transportation that the amount of coal would not justify the expense of opening up the coal for delivery to large markets. The coal will probably be mined by country banks for local consumption. In computing the tonnage of the area the thickness is assumed to be 52 inches.

The mining area E-1, located in Pennsylvania south of Paris, is here omitted.

Mining Area, E-2. This area includes the coal on the ridges in the northeastern part of Brooke county, which give a total of 183 acres, containing 1,385,000 tons of coal.

Mining Area, E-3. The ridge which reaches Harmon creek one mile and a quarter below the town of Collier contains a body of coal that may justify development on a commercial scale. Here the coal outcrops three-tenths of a mile north of the creek and 390 feet above it. This coal could be delivered by an incline to the railroad. The area contains 419 acres and 3,164,000 tons of coal.

Mining Area, E-4.—This division is made to include the scattering small areas northeast of New Cumberland Junction. They collectively contain 147 acres with 1,115,000 tons of coal.

Summary.—In the portion of the Steubenville quadrangle in West Virginia there are 138,800,000 tons of Pittsburg coal. The location of the coal areas with reference to the present lines of transportation is such that 131,501,000 tons may be considered available to the world's markets without further railroad construction except short spurs necessary to reach mine openings. The average thickness of the coal is 56 inches. The fixed carbon averages about 50, the ash 9, and the sulphur between 3 and 4 per cent.

COALS OF THE CONEMAUGH AND ALLEGHENY FORMATIONS.

Below the base of the Pittsburg coal, occur the Conemaugh rocks. These measures are not productive in valuable coal seams; though within the Steubenville quadrangle, they carry two coals of economic importance over very limited areas.

Blanche Seam.—On the north side of Harmon creek just west of Colliers town, a coal seam in the lower portion of the Conemaugh has been operated for fuel for the Pennsylvania railroad. The horizon of this seam is about 100 feet below the Ames limestone. The coal averages four feet, six inches in thickness with a maximum of six feet in places. The lower three feet and a half is very hard and of good quality, with a foot of soft coal above. The roof is slate and very good quality, while under the coal is a shaly sandstone. In the development of the mine a heavy clay seam was encountered to the north, and the mine has been entirely abandoned.

Finley Coal.[1]—This coal derives its name from the Finley farm on Island creek, Ohio. The seam is very irregular in thickness, varying from 0 to 60 inches, which maximum it holds only for a short distance. A sample from the mine on this farm has the following composition:

Moisture	3.89
Volatile matter	36.36
Fixed carbon	52.25
Ash	7.40
Sulphur	3.63
Total	100.00

1. This coal is called the Mahoning in other chapters of this report.—G. P. G.

In West Virginia, one mile southeast of Zalia, a local coal bank is opened on the farm of J. F. Swearingen. The coal has a thickness of 43 inches, and near the center of the seam is a band of sulphur which is said to break easily from the coal. A sample from this bank gave the following result upon analysis:

Moisture	4.15
Volatile matter	36.76
Fixed carbon	49.91
Ash	9.18
Total	100.00
Sulphur	5.10

This seam is probably the same as the Finley of Island creek.

Kings Creek Coal.[1]—In the valley of Kings creek, near the junction of the two forks of that stream, a coal seam occurs that is of considerable local importance. The seam is four to six feet in thickness and of very good quality. The coal is used by the oil well drillers in the surrounding territory. Its outcrop at the forks of Kings creek is 780 feet above tide and 287 feet below the Ames limestone.

From the forks the outcrop is believed to have been followed step by step down Kings creek. On the road to Cumberland Junction the coal elevation is 745. On the north side of the road at the south bend of Kings creek the elevation is 757 feet. The seam is here positively identified as the Roger coal, with an interval of 343 feet below the Ames. If this coal has been correctly followed down Kings creek the interval between the Ames limestone and Roger coal varies 56 feet in two miles. This condition is so exceptional that the writer hesitates to accept the view that the Kings creek coal is equivalent to the Roger seam, but believes there is a strong probability that it is the Lower Freeport and not the same seam that outcrops at the iron bridge and southern bend of Kings creek. The important question of the correlation of the Finley, Kings creek, and Roger coals will be omitted until further field work, and the conclusions will be published in the Folio report of this area by the U. S. Geological Survey.

Roger Coal.—This seam, which is known as the shaft seam about Steubenville, is second in importance to the coal beds of the

1. This coal is called the Lower Freeport in other chapters of this report.—G. P. G.

quadrangle. It has been correlated by Dr. Edward Orton as equivalent to the Lower Freeport of the Pennsylvania series (Ohio Geol. Survey, Vol. V, p. 49). The writer is not prepared to accept this correlation as proved. The thickness of the seam varies from three to five feet, with an average of about three feet six inches. The coal has a slate parting from six to 14 inches from the bottom of the seam, the lower bench being of poor quality and high in sulphur. It is in this bench that the variation in thickness of the seam is found.

At Gilligan's bank on the edge of Toronto this coal has a thickness of 30 inches, with a parting 14 inches from the bottom. Only the upper bench of 24 inches is mined. At Steubenville Coal and Mining Company's shaft the coal varies from four feet three inches to four feet ten inches, and has a two-inch slate parting 14 inches from the bottom of the coal. Below this parting the coal is high in sulphur, while the upper bench is of very good quality. At the La Belle Iron Works shaft in Steubenville the coal is 42 inches in thickness, with the lower eight inches high in sulphur. It is burned as a steam coal, and with exception of the lower eight inches is used in the gas producer.

At Brilliant, Ohio, the Jefferson Coal Company is mining the Steubenville shaft seam, three to five feet thick, with an average of three feet nine inches. The quality is excellent for a steam and gas coal. It is hard and breaks up in the mine when shot. To the north of the shaft there is a slate band of one inch 15 inches above the bottom of the coal; while to the south of the shaft there are two bands of slate, nine and eighteen inches from the bottom. The lower nine inches is the poorest coal in the mine, and the undercut is made above this layer at the first slate.

The estimate of quantity of coal in the Roger seam in the Steubenville quadrangle must be based on meager information. It would appear from the study of the stratigraphy that one-fourth of the quadrangle is underlaid by this coal in workable thickness. If an average thickness of three feet is assumed, and the weight is the same as the Pittsburg coal, there would be an area of 36,411 acres, containing 189,890,000 tons of coal.

The amount of coal in the Finley seam is problematical. The writer feels disposed to estimate an area of 2,500 acres, with a

thickness of four feet, which would be equivalent to 17,424,000 tons.

The Steubenville quadrangle (including the areas in Pennsylvania, West Virginia, and Ohio) is therefore estimated to contain:

Pittsburg coal	320,590,000	tons
Roger coal	189,890,000	"
Finley coal	17,474,000	"
Total	527,954,000	tons

CHAPTER IX.

PETROLEUM AND NATURAL GAS IN THE PAN HANDLE COUNTIES.

West Virginia is one of the leading States in the Union in the production of petroleum and natural gas, holding second rank in each in value. The oil production culminated in 1900 when it reached 16,195,675 barrels, and has declined since that time. The production in 1904 was 12,644,686 barrels, and 11,578,110 barrels in 1905.

Less than one-half of the natural gas production is utilized in the State, according to the statistics of the U. S. Geological Survey for 1905, as shown below:

Value of production	$10,075,804
Consumed in the State	3,586,608
Sold in other States	$6,489,196

When the above table is compared with conditions in Ohio there is a marked contrast.

Consumption of gas in Ohio	$10,396,633
Production in Ohio	5,721,462
Secured from other States, especially from West Virginia	$4,675,171

The State of West Virginia is thus contributing a large and valuable fuel supply to foster and maintain industries in neighboring States, which is a serious detriment to its own industrial development, and for which there appears at the present time to be no legal remedy.

Whether a State has the right to hold within its borders any of its natural resources for the upbuilding of its own industrial welfare in preference to permitting this supply to be drawn away to other States to their advantage is a very much disputed ques-

tion. If such a law could be enacted and prove to be constitutional it would bring a very great development in new industries to this State.

The United States is the great oil and gas country of the world. Over one-half of the crude oil is produced here and nearly three-fourths of the refined product, while 99 per cent. of the natural gas of the world is utilized in this country. It is therefore natural to look to American men of science for the solution of the problems connected with these mysterious sources of heat and light.

While to the United States belongs the credit of the practical development of the oil and gas industry, the discovery and first crude utilization of these substances belongs to the Orient. They were in use long before a western continent was known to exist, or was even dreamed of in the wildest flights of imagination. The date of their discovery is lost in the darkness of antiquity. The modern oil and gas development is to be found, however, in America, and here have been evolved the methods of drilling, refining, transporting, and utilizing these sources of luxury and wealth.

The modern oil development began in 1859 with the completion of the Drake well in the Oil creek valley of Pennsylvania, and in the next ten years the successful search for oil was made over the country from the Appalachians to the coast of California, resulting in a wonderful development.

The history of petroleum in West Virginia dates from the early days of the last century, when the oil scum removed from the surface of the oil springs along the Great and Little Kanawha rivers was sold by the quart and gallon as a cure for the ills of mankind. The first well bored for oil in the State was completed in 1860 near Burning Springs, on the Little Kanawha. A few of the wells drilled in this area in these early days are to-day, according to Dr. I. C. White, producing one to two barrels daily, although 45 years old.

The real development of the petroleum industry in West Virginia began in 1889 with the opening of the Dolls Run, Eureka, and Mannington oil pools, and culminated in 1900. The history of this development and a general discussion of the subject of oil

and gas in this State are given in Volume I-a of the reports of the West Virginia Geological Survey.

The modern development of the natural gas industry began in 1887 with the opening of the northern Ohio and Pennsylvania fields and their utilization.

ORIGIN OF PETROLEUM AND NATURAL GAS.

When gas and oil were noted in the earliest records of history, they were looked upon as curiosities, and few attempts were made to inquire into their origin. They were supposed to spring from the earth's interior, and being objects of religious worship, their origin was not to be questioned by man.

After the modern development of the great oil fields of the United States and Russia, scientists gave more attention to this question of origin, and a number of theories were advanced, which may be grouped under two divisions, *chemical* and *geological*.

Chemical Theories.

The first clear statement of the chemical theory of origin of oil and gas was given in 1866 by Berthelot, the renowned French chemist, who assumed that at the center of the earth there were large masses of alkali metals (potassium and sodium), and the carbonic acid gas carried from the air in rain water passed downward into the earth until it finally reached the heated zone where these metals were present. There would then result chemical action whereby petroleum and tar-like substances would be formed. Similar results have been produced in the laboratory.

The theory has never attracted general attention on account of the lack of proof that these metals exist in any quantity in the interior of the earth; and while, if all these conditions were present, such products would be formed, the theory is very doubtful.

The next statement of the chemical theory was given by the great Russian chemist, Mendeljeff, in 1877. The specific gravity of the surface rocks of the earth averages 2½, while that of the earth as a whole is over 5. Mendeljeff and his followers concluded that the interior portion of the globe must be composed of heavier substances. Iron, with a specific gravity of over 7, seemed to best accord with the requirements. Now iron in a

molten state in contact with the carbonic acid in rain water would give the reaction to form petroleum compounds similar to that given by Berthelot.

This theory attracted much favorable attention among foreign chemists, but not among geologists. The thin crust theory once so popular has been cast aside as inconsistent with other phenomena and forces of the earth. The theory of heavier substances at the center of the earth finds few upholders at the present day. The greater density of the earth as a whole over that of the surface rocks is now explained by the great pressure on the interior masses by the overlying layers, thus causing greater compression of the rocks, therefore a higher density or gravity.

It is, perhaps, unfortunate that these theories are not true, for by them the oil and gas would be continually forming and there would not result any exhaustion of the fields, or if exhausted it would only be necessary to rest the wells until the supply was renewed.

Geological Theories.

Mr. Eugene Côste, an eminent Canadian mining engineer, has in recent years advanced a theory of volcanic origin of oil and gas, and believes these deposits are volcanic products condensed and held in their passage upward in the porous rocks of all ages, and he states "nothing is so simple, and therefore so natural, as this origin."

The volcanic theory has not been accepted in the United States, and most geologists of this country accept the organic theory of origin, though there is considerable difference of opinion as to the method of formation from organic substances. It was suggested by Newberry that the oil was a product of slow distillation of carbon-bearing rocks at low temperatures, similar to the distillation of gas from coal, except that the temperature was low. The objections to the theory are the absence of a coke residue in the earth, and the presence of sufficiently high temperature for the reaction in rocks which show no effects of such temperature.

The more generally accepted theory holds that the vegetable and animal remains in a process of decay formed gaseous and oily compounds, which were imprisoned in the soft sediments along the seashore or in lakes and rivers, and later when these sediments

were consolidated into solid rock these rocks still held the imprisoned gases and oil. In other words the oil and gas were formed at or near the time the rock sediments were deposited in which they are now found. The process of oil formation, according to this theory, ceased long ago in all but the more recent rocks.

The origin of gas and oil is not one of the solved problems, but still belongs to the realm of theory, and the above theory appears to be the best one formulated so far, and is based on many lines of evidence, and probably should be accepted until a better one is advanced. Whatever the origin, every experienced person knows the oil and gas fields are not perpetual producers, and their day and generation are but brief. In the words of the late Dr. Edward Orton, when these fields begin to live in history they begin to die. Extravagant waste of oil and gas is extravagant loss, not to be replaced by nature. When these fields are exhausted the gas and oil history of that locality is a past history for all time. Ten years' rest, or a hundred, will not repair the damage, and from all we now know or can judge, a thousand or ten thousand years will not alter the situation.

Geological Conditions for Accumulation.

If gas or oil are present in the rocks of a given locality and distributed uniformly through these rocks over a wide area the total quantity of oil or gas would be very large, while the available supply in a well might be nothing. According to Dr. Edward Orton, if rocks contained one-tenth of one per cent. of oil a square mile of rock 500 feet in depth would contain 2,500,000 barrels, or about one-third of the greatest production per square mile of any of the leading fields of the country.

Dr. I. C. White has estimated that "the amount of oil obtainable from a good producing sand in West Virginia will not average more than a gallon to the cubic foot, and also that the depth or thickness of *pay streaks* will not average more than five feet, and taking these factors as a basis, we would get about 5,000 barrels of 42 gallons each to the acre as the total production of fairly good oil territory."[1]

1. W. Va. Geol. Survey, Vol. 1-a, p. 46.

In order to have an accumulation of oil and gas four conditions are necessary. There must be a *reservoir;* not necessarily, and probably never, in the form of a cavern, but in the form of a porous rock, in which the oil and gas are held in the interspaces of the rock. Such a rock is found in the Indiana and Ohio fields in the form of a porous magnesian limestone. In Pennsylvania, West Virginia, southeastern Ohio, and Kansas the reservoir is a sandstone. Such a porous sandstone is never empty, but it will contain water, oil or gas.

Second, there must be a tight *cover* or the products will escape upward and be lost. This cover is usually in the form of a compact shale varying in thickness from a few feet to several hundred. When this cover is penetrated by the drill the gas or oil released and under heavy pressure may reach the surface, in many cases raising the heavy drilling tools.

Third, there must be *pressure* to force the gas or oil out of the rock. This rock pressure in gas wells forces the gas to the surface and out through the mains. It varies from less than a pound to 1,500, in some of the West Virginia wells when first drilled. This pressure is popularly supposed to bear a direct relation to the volume of gas in the well, but it cannot be used for accurate estimates. In many cases a well with lower rock pressure may have a larger volume than one with higher pressure. The open flow pressure which is very much lower in amount is used in accurate measurements of volume.

The cause of the rock pressure is a subject of dispute. In Ohio and Indiana there seemed to be an artesian water pressure back of the gas, which agreed closely with the gas pressure recorded. In the high pressure wells of West Virginia this theory fails. The only explanation offered for such wells is that the gas in the rocks is under compression, and when released by the drill the expanding gas exerts its own pressure, increased by any water pressure that may be present back of it.

A fourth condition for a long time a subject of controversy is *rock structure.* A fold in the rocks would give a favorable place for the accumulation of gas and oil, which without the fold might be distributed equally throughout the reservoir rock. The gas and oil fields of this State, Pennsylvania, Ohio, Kentucky, and

many other sections, have been proved to be associated with folds in the rocks. Doctor Noettling's studies on the famous Burma, India, oil fields, published in 1895, showed the structure existed there. In West Virginia, Dr. I. C. White has made many successful well locations near the folds, and Dr. Edward Orton had similar success in Ohio, and to these men belongs the credit for establishing the theory in practical work.

The anticlinal theory of oil and gas accumulation advanced as a theory has become a valuable working rule, and most oil men have come to recognize this factor. A careful review of the theory and its application are given in the oil and gas report of this Survey.

Value of Natural Gas Compared with Coal.

Laboratory experiments in Ohio and Pennsylvania showed that about 20,000 cubic feet of natural gas was equal to one ton of Pittsburg coal, and these figures are usually given to show the value of gas for fuel.

A less amount of gas heat energy will escape through the pipe and chimney in the form of soot and smoke than when coal is used. In other words, the combustion of gas will be practically more complete in the stove or furnace than when coal is used. Observations on the use of coal under a boiler for a given length of time, and also on the use of gas for the same period, seem to show that about 12,000 to 15,000 cubic feet of gas will be equivalent to a ton of coal. The exact practical equivalent cannot be stated on account of many variable factors.

The chemical composition of natural gas, a general discussion of the chemistry and heating value, are given in Volume I-a (pp. 513-557) of the reports of the Survey.

The Oil and Gas Horizons of West Virginia.

Dr. I. C. White, in the volume mentioned above (p. 506), groups together the oil and gas horizons of the State as follows:

Carboniferous	Monongahela Series.	Carroll sand.
	Conemaugh Series	Moundsville (Morgantown). First Cow Run sand, Upper and Lower. Dunkard sands.
	Allegheny Series	Second Cow Run sand. Gas sand of Marion and Monongalia counties.
	Pottsville Series	Gas sand of Cairo. Salt sand, Cairo. Cairo?
	Mauch Chunk Red Shale.	(Maxton, Cairo?)
	Greenbrier Limestone.	(Beckett sand of Milton?)
	Pocono Sandstone	Keener sand. Big Injun sand. Squaw sand.
Devonian	Catskill Red Beds	Gantz sand (Berea Grit). Fifty-foot sand. Thirty-foot sand. Stray sand. Gordon sands. McDonald or Fifth sand. Bayard or Sixth sand.
	Chemung, Hamilton and Corniferous Beds	No well defined oil or gas horizons yet discovered in West Virginia, but found in Pennsylvania.

OIL AND GAS DEVELOPMENT IN THE PAN HANDLE COUNTIES.

Ohio County.

For many years wells have been drilled in Ohio county in a search for oil and gas. The results have not been very encouraging, although small quantities of gas have been found and indications of oil. Up to the close of the field work in this county there were no producing oil wells, and no gas wells except as used for a local supply for the farms on which they were located. The Tri-State Natural Gas Company, Natural Gas Company of West Virginia, and Wheeling Natural Gas Company, lines cross the county and furnish a supply of gas to Wheeling, the various towns, and farmers through most of the county.

It has been reported that a good gas well was struck during the past fall near Potomac, in the northeastern part of the county, and that further drilling would be carried on in that section. A few years ago gas was found in a number of wells near Twilight, on Middle Wheeling creek, and connected with the main pipe line along the National road. The pressure soon declined and gas from the main line was forced back to the wells, which were then disconnected and are now used locally by the people of that section.

Most of the prospect wells drilled in Ohio county have been located here and there, and the failure of the first well caused the removal of the outfit to another often distant location. The records of these wells, for the most part, have been lost, or at least are not available.

In the past, there has been a considerable amount of leasing of lands, but the amount of prospecting work has been small in comparison with the area. It has not been systematic enough or sufficient to encourage or condemn the county as possible gas and oil territory. The records of wells as far as it has been possible to obtain them are included in this chapter.

Early in 1904 a large gas field was opened in the northeastern part of Marshall county by the Virginia Oil and Gas Company of Wheeling. This field is on Wheeeling creek, near the mouth of Grandstaff run, three to three and one-half miles south of Elm Grove, in the Sand Hill district.

The productive horizon, according to Dr. I. C. White, is "700 to 725 feet below the Pittsburg coal, and hence is possibly identical with the 'Gas' Sand of Marion and Monongalia counties, which generally represents the extreme top of the Pottsville formation, or Homewood sandstone member of that series, though occasionally it is the Freeport sandstone of the Allegheny formation."[1]

Maria Downing Heirs' Well, No. 1.

The following well records of this field are taken from the report above quoted:

	Feet.	Feet.
Shale	15	
Top Lime	42	
Bottom Lime	93	
Coal (Sewickley)	123	to 124½
Pittsburg Coal	211	to 217
First Cow Run Sand (Saltzburg)	517	to 553
Second Cow Run Sand (Dunkard)	708	to 742
Salt Sand	904	

"Gas on top and best well in this field, about 5,000,000 cubic feet and rock pressure 475 pounds."

Silas Davis Well, No. 1.

Three and one-half miles southeast of Elm Grove Postoffice. Authority, Virginia Oil and Gas Company.

	Feet.	Feet.
Top Lime	40	
Pittsburg Coal	221	to 227
First Cow Run Sand (Saltzburg)	527	to 537
Second Cow Run Sand (Dunkard)	723	
Salt Sand	924	to 970

"Struck oil at about 945 feet, and shot with 60 quarts below this depth, which shut off the oil and opened up the gas."

William Miller Well, No. 1.

Three and one-half miles southeast of Elm Grove Postoffice. Authority, Virginia Oil and Gas Company.

1. W. Va. Geol. Survey, Vol. 1-a, p. 225.

	Feet.	Feet.
Shale	10	
Top Lime	38	
Bottom Lime	88	
Coal (Sewickley)	120 to	121½
Pittsburg Coal	206 to	212
First Cow Run Sand (Saltzburg)	512 to	540
Second Cow Run Sand (Dunkard)	708	
Salt Sand	900 to	937
Gas at	937	

"Utilizing the gas for drilling purposes, and being piped to Elm Grove for use. Probably 2,000,000 feet with rock pressure of 260 pounds."

George P. Folmar Well, No. 1.

Three miles southeast of Elm Grove Postoffice. Authority, Virginia Oil and Gas Company.

	Feet.	Feet.
Top Lime	40 to	40
Pittsburg Coal	198 to	202
Cave (water)	300	
First Dunkard Sand (Saltzburg)	500 to	520
Second Dunkard Sand	700 to	740
Salt Sand	900 to	960
"Broken" (shale, etc.)	960 to	1,050
Maxton (?) Sand	1,050	
Flow of Gas at	1,050	

"Good flow of gas, but abandoned."

Dr. I. C. White regards the sand at 1,050 feet, called the Maxton by the driller, as most probably a member of the Pottsville above the Maxton horizon.

The deepest boring made in West Virginia is the Boggs Run well, three miles below Wheeling, drilled by the Wheeling Development Company, and a careful record was preserved by J. C. Brady, secretary of the company.

This well was 4,500 feet deep, and very careful tests of temperature were made by Dr. Hallock of Columbia University, New York. He found a temperature of 110.3° F., at the bottom, while the top was 51.3° feet, an increase of 1° F. for every 74.3 feet, though in the lower half of the well the increase was 1° F. for every 60 feet.

The Washington coal, according to Dr. I. C. White, crops 40 feet above the level of the derrick floor, giving 364 feet between

1. W. Va. Geol. Survey, Vol. I. p. 365.

this coal and the Pittsburg, which agrees with the measurement at Chapline Hill, Wheeling. This interval increases to 460 feet at Pine Grove, Wetzel county, 25 miles south.

The record of this deep well as given in Volume I (pp. 364, 365) of the Survey reports is as follows:

Boggs Run, Deep Well.

On Boggs run, near Wheeling, as interpreted from samples of the drillings:

	Feet.		Feet.
Unrecorded	275	to	275
Limestone and coal	8	to	283
Limestone	32	to	315
Shale, gray	5	to	320
Limestone	4	to	324
Pittsburg coal	6	to	330
Gray sandy shale	30	to	360
Gray sand	8	to	368
Greenish gray slate	12	to	380
Red shale	30	to	410
Red and brown shale	34	to	444
Unrecorded	40	to	484
Gray sandy shale	6	to	490
Unrecorded	10	to	500
Red shale	250	to	750
Shale, red, coal, etc	110	to	860
Coal, Upper Freeport	4	to	864
Sandstone, gray	45	to	909
Coarse gray sandstone	83	to	992
Fine white sandstone	408	to	1,400
Coarse gray sandstone	60	to	1,460
Fine white sandstone	90	to	1,550
Very hard white sandstone (base of "Big Injun")	20	to	1,570
Dark gray shale	330	to	1,900
Gray sandy shale	110	to	2,010
Gray and red shales	100	to	2,110
Gray and blue shales and sandy beds	350	to	2,460
Dark gray sandy beds	60	to	2,520
Gray sandy shells	180	to	2,700
Unrecorded	175	to	2,875
Light gray shale	80	to	2,955
Light gray sand bed (slight show of oil)	40	to	2,995
Gray and dark shale	80	to	3,075
Gray sandy shale	125	to	3,200
Shale, gray	60	to	3,260
Shale, dark	80	to	3,340
Shale, dark gray	160	to	3,500
Shale, light gray	75	to	3,575
Shale, gray	375	to	3,950
Shale, soft, gray	50	to	4,000
Shales, dark, sandy, with an occasional shell to bottom	500	to	4,500

The following record is given in the volume quoted above (p. 366) of the Central Glass Company well near its factory in East Wheeling, on Wheeling creek:

Central Glass Works Well, Wheeling.

Well begins 75 feet under Pittsburg coal.	Feet.		Feet.
Well begins 75 feet under Pittsburg coal	75	to	75
Variegated shales with little sand	280	to	355
Coal	1	to	356
Sandstone, etc., not recorded	200	to	556
Coal (Steubenville shaft coal)	7	to	563
Sandstone and other rocks	96	to	659
Coal (one of the Kittannings)	5	to	664
Shells and hard gray sandstone	112	to	776
Sandstone, white, top of No. XII (gas near bottom)	70	to	846
Sandstone, fine-grained, yellowish-gray (oil at bottom)	50	to	896
Sandstone, coarse, hard, yellowish-gray (oil and gas at 1,000 ft. Maxton)	170	to	1,066
Sandstone, brown, coarse ("Big Injun")	139	to	1,205
Shale, black	45	to	1,250
Sandstone ("Squaw" sand)	25	to	1,275
Unrecorded	330	to	1,605
Sandstone, fine-grained, brown (Berea Grit)	10	to	1,615
Unrecorded to bottom, no definite sands	480	to	2,095

The following record of the Laughlin deep well at Martin's Ferry, opposite North Wheeling, is taken from Dr. Edward Orton's report, and the derrick floor is about 60 feet below the Pittsburg coal:[1]

Laughlin Well, Martins Ferry, Ohio.

	Depth. Feet.	Thickness. Feet.
Black slate	240	50
Gray sand	290	50
White sand	340	60
Black slate	400	12
Gray sand and first gas	412	14
Coal, impure	426	12
Shell, salt water and gas	438	7
Shale	445	25
Shell	450	5
Coal, good	480	5
White sand	485	145
Black slate	630	20
White slate	650	10
White sand	660	170
Dark gray sand, cased at 830	830	10
Limestone	840	15
Sand, oil and gas at 985	855	280
Black shale	1,135	130

1. Ohio Geol. Survey, Vol. VI, p. 405.

Sand shell	1,265	12
Black slate	1,277	253
Black sand	1,530	160
Slate and shells	1,590	20
Red rock	1,610	25
Black slate	1,635	10
Slate and shells	1,645	5
Blue sand	1,650	10
Red rock	1,660	10
Black slate	1,670	5
Shell	1,675	421
Black slate	2,096	40
Shell	2,136	164
Black slate	2,300	

According to Dr. Edward Orton's interpretation of this record, the limestone at 845 feet is the Sub or Lower Carboniferous, giving 845 feet for the thickness of the Coal Measures. The black sand at 1,530 feet represents the Berea Grit, 130 feet in thickness.

Three miles above the mouth of Wheeling creek a well was bored on the Judge Thompson farm by a Pittsburg company. Dr. I. C. White states that the 360 feet of white sand from 855 to 1,215 feet undoubtedly holds a portion of the Pottsville, as well as all of the Big Lime, and all of the Big Injun Sand. The record is given as follows (Vol. I-a, p. 231):

Judge Thompson Well.

	Feet.		Feet.
Interval from Pittsburg Coal	45	to	45
Drive pipe	41	to	86
Slate	50	to	136
Sand	150	to	301
Red rock	20	to	321
Sand, gray	10	to	331
Red rock	25	to	356
Slate	39	to	395
Coal (Bakerstown)	2	to	397
Slate	148	to	545
Sandstone	100	to	645
Coal	4	to	649
Sand, white	176	to	825
Sand, black, with mineral water	15	to	840
Slate	15	to	855
Sand, white	360	to	1,215
Slate and shells	430	to	1,645
Red rock	35	to	1,680
Slate and shells	355	to	2.035
Slate and shells	250	to	2,285
Sandstone	20	to	2,305
Slate and shells	130	to	2,435
White slate to bottom of boring	10	to	2,445

The 360 feet of white sand reported from 855 to 1,215 undoubtedly holds a portion of the Pottsville, as well as all of the Big Lime (here sandy) and all of the Big Injun Sand.

Near Twilight, on Middle Wheeling creek, seven miles southeast of Wheeling, the Natural Gas Company of West Virginia drilled a number of gas wells of small volume which are now used at the farm houses of that section. The following records of these wells have been furnished the Survey by Mr. G. F. Batchelor, secretary of the company:

Hohman Well, South of Twilight.

	Feet.
Conductor	9
First coal (Sewickley)	170
Second coal (Pittsburg)	252
Cased with 6¼-inch casing	299
Cased with 4⅝-inch casing on top of "Hurry-up" Sand	727
Struck a little gas at	756
Passed through "Hurry-up" Sand	769
Struck sand at	1,000
Some gas at	1,002
More gas at	1,006
Filled up with salt water at	1,010
Total depth of well	1,010

Gantzer Well, North of Twilight.

	Feet.
Conductor	18
First coal (Sewickley)	125
Second coal (Pittsburg)	205
6¼-inch casing	250
Cased with 4⅝-inch casing on top of "Hurry-up" sand	705
Passed through "Hurry-up" sand	736
Struck "Salt" sand	940
Struck gas and finished	964

Wagner Well, East of Twilight.

	Feet.
Conductor	21
First coal (Sewickley)	89
Second coal (Pittsburg)	169
Water	179
Cased with 7½-inch casing	216
Cased with 4⅝-inch casing on top of Dunkard sand	658
Struck gas	692
Total depth of well	715

Plate XII.—Lower Freeport Sandstone with Lower Freeport Coal Showing Above. Casparis Quarry, Kings Creek, Hancock County.

Fleahman Well, at Twilight.

	Feet.
Conductor	16
First coal (Sewickley)	90
Second coal (Pittsburg)	180
Cased with $7\frac{1}{2}$-inch casing	194
Cased with $4\frac{5}{8}$-inch casing on top of Dunkard sand	664
Struck gas	710
Total depth of well	722

The Waynesburg coal crops in the hill 87 feet 10 inches by hand level above the derrick floor at the Fleahman well. This would make an interval of 267 feet 10 inches between the coals, which agrees closely with intervals measured in the eastern portion of the county. The interval between the Sewickley and Pittsburg coals is 90 feet in the Fleahman well and 80 feet in the others.

The gas sand designated by the drillers in this locality, on account of the more open character of the rock and therefore more rapid drilling, the "Hurry-up" sand, is 475 (Hohman) and 500 feet (Gantzer) below the Pittsburg coal, while the sands called the "Dunkard" in the Wagner and Fleahman wells are 489 and 484 feet below the coal, which show the sands to be the same in the four wells, and probably represent the "Little Dunkard sand" of Wetzel county, which belongs at the horizon of the Upper Mahoning sandstone near the base of the Conemaugh series. The thickness of this series in the northern portion of the Pan Handle area is 500 feet. The thickness of this sand in these wells runs from 31 (Gantzer) to 46 feet (Fleahman).

The Dodds well was drilled 2,735 feet deep, and was located on the west bank of Middle Wheeling creek, about 300 feet below the mouth of Gillespie run, one mile and a half east of Twilight and eight miles and a half southeast of Wheeling. A very complete log has been preserved and furnished to the Survey by Mr. J. S. Ferguson of Valley Grove, Ohio county.

Dodds Well on Middle Wheeling Creek, Ohio County.

	Feet.	Thickness. Feet.
Conductor	11½	
First coal (Waynesburg)	14½	
Second coal (Sewickley)	208	
Pittsburg coal	296	6
Hurry-up sand	490	40
Cow run sand	770	20
White sand	925	75
Coal (one of the Kittannings)	968	6 to 9
Gas sand	1,128	
Casing 6¼-inch at	1,130	
Salt sand	1,168	50
Salt sand	1,268	
Top of Big Injun sand	1,362	
Bottom of Big Injun sand	1,678	316
Top of slate and sand	1,950	
Bottom of slate and sand	1,965	15
Top of Berea sand	2,015	
Bottom of Berea sand	2,035	20
Top of limestone	2,040	
Bottom of limestone	2,070	30
Top of red limestone	2,100	
Bottom of red limestone	2,165	65
Top of red stone cave	2,225	
Bottom of red stone cave	2,260	35
Top of Gordon stray sand	2,330	
Bottom of Gordon stray sand	2,338	8
Top of "pencil cave"	2,380	
Bottom of "pencil cave"	2,385	5
Shell rock, Gordon sand	2,390	
Bottom of Gordon sand	2,410	20
Top of coarse gray sand	2,483	
Bottom of coarse gray sand	2,490	7

No more sands found, shale and limestone to bottom of well at 2,735.

This record gives the Waynesburg-Pittsburg coal interval as 282½ feet, which is larger than farther east in the county. The "Hurry-up" sand, 194 feet below the Pittsburg coal, is about the horizon of the Morgantown Sandstone. The sand designated as "Cow Run" in this section, 474 feet below the Pittsburg coal, is apparently the same as the Hurry-up sand at Twilight, corresponding to the Upper Mahoning sandstone.

The coal at 968 feet or 672 feet below the Pittsburg is at the Kittanning coal horizon, and the heavy white sand 43 feet above, is near the Lower Freeport sandstone horizon. The coal is reported by the driller as six to nine feet thick.

The gas sand at 1,128 feet and 160 feet below the Kittanning coal would correspond to the top of the Pottsville. The Big Injun sand, 316 feet in this record probably includes the Maxton and Big Injun. The Berea sand in this well is 20 feet, with its top 1,719 feet below the Pittsburg coal, and below it comes the Devonian limestone. The Gordon sand occurs at 2,390, with the "stray" sand 60 feet higher. The coarse gray sand at 2,483 is probably the McDonald, or Fifth Oil Sand. The well was drilled 245 feet lower, but no more sands were found, and the driller states the rocks were shales and limestone.

The Carter Oil Company drilled in the fall of 1903 on the J. N. McGlumphy farm on Coulter run, two miles southeast of Valley Grove. The record was kept of the sands from Pittsburg coal down and has been furnished by the company.

J. N. McGlumphy Well, No. 1, Coulter Run.

	Depth. Feet.	Thickness. Feet.
Pittsburg coal	435	4
Cave	670	70
Cow Run sand	745	40
Salt sand	1,105	220
Maxton sand	1,390	80
Big Injun sand	1,530	285
Berea Grit	2,170	15
Gordon sand	2,440	3
Fifth sand	2,555	10
Total depth	2,725	

The Cow Run sand of this record is 310 feet below the Pittsburg coal, while this sand in the Dodds well is 474 feeet, and further south in Marshall county it is 508 feet. The horizon in the McGlumphy well would better accord with the Saltzburg sandstone.

The Salt Sand is 360 feet lower, or 670 feet below the Pittsburg coal, and is therefore near the horizon of the white sand (925 feet) in the Dodds well, probably the Lower Freeport sandstone. The Berea Grit is 1,735 feet below the Pittsburg coal, which agrees closely with the Dodds well. The Fifth Sand would come near the Gordon horizon, while the Gordon of above log would be the "Stray."

This correlation would give 385 feet interval between the Berea and Gordon sands as compared with 375 feet in the Dodds

well and 364 feet in the Richmond well near Majorsville, in Marshall county.

A record of the John Armstrong well near the forks of Turkey run, in the northeastern corner of Marshall county, and one mile southwest of Dallas, has been received from Mr. S. D. McCloy.

John Armstrong Well, on Turkey Run, Marshall County.

	Feet.	Feet.
Casing, 13-inch	82	
Coal (Waynesburg)	270	
Coal (Sewickley)	500	
Pittsburg coal	586	
Casing, 10-inch	960	
Gas sand (gas at 1,300 feet)	1,290	to 1,440
Salt sand, Maxton (casing 8-inch at 1,505)	1,480	to 1,680
Big lime (casing 6⅝-inch at 1,690)	1,680	to 1,710
Big Injun sand	1,710	to 1,985
Thirty-foot shells (Berea?)	2,260	to 2,375
Red rock	2,435	
Fifty-foot, all shells	2,450	to 2,490
Gordon sand, all shells	2,545	to 2,555
Fifth sand (a little gas at 2,695)	2,693	to 2,700
Slate and shells	2,700	to 3,108
Total depth	3,108	

The well was plugged with three plugs at 1,765 feet.

The Waynesburg-Pittsburg coal interval gives 316 feet as the thickness of the Monongahela Series, or 34 feet greater than in the Dodds well, three miles northwest. Gas was struck at 1,300 feet and is still escaping from the well. This sand is 704 feet below the Pittsburg coal, which would probably correspond to the gas sand at 1,003 feet in the Richmond well at Majorsville a few miles south (record given Vol. I-a, p. 227), and would represent one of the salt sands of the Pottsville Series.

The salt sand at 1,485 feet with the "Big Lime" (Greenbrier) below, would correspond to the Maxton. The Big Injun sand is 1,124 feet below the Pittsburg coal as compared with 1,066 feet in the Dodds well, and 1,095 feet in the McGlumphy.

The "Thirty-foot shell rock, would come about the Berea horizon in its interval below the Big Injun, and above the Gordon. The base of this formation is 1,789 feet below the Pittsburg coal, and in the McGlumphy the distance is 1,750 feet, and 1.740 feet in the Dodds well.

An oil well was drilled on the Dixon farm west of West Liberty, in the northern part of Ohio county, in the spring of 1901 and a record of the coals was kept by S. S. Jacobs, as follows:

	Feet.	Feet.
Coal, Redstone	4 at	35
Coal, Pittsburg	5 at	75
Coal, Bakerstown	6 at	396
Coal, Lower Freeport	6 at	666
Coal, Middle Kittanning	10 at	721
Coal, Lower Kittanning	8 at	760

Accepting the identification by the driller of the Pittsburg coal, the coals would be correlated as above, but this well was not visited in the course of the present work.

OIL AND GAS IN BROOKE COUNTY.

Attention was directed to the gas field at Wellsburg, West Virginia, and Brilliant, across the river, in Ohio, by the drilling of the Barclay gas well just south of Wellsburg, in 1882. This well was ruined by the flood of 1883, and other wells were drilled in 1883 and 1884 with varying success, and the field was looked upon as exhausted in 1885.

An excellent review of the recent oil development in Brooke county has been written by T. W. Carmichael of Wellsburg, and the following facts have been taken from this article. The first profitable oil well in the county was on the farm of Robert Underwood, July 15, 1902, near the mouth of Jordan run, in Buffalo district. It was called a thirty-barrel well, and a second one was drilled on the same farm to the south of the first, and was a fair producer. A third well to the east came in dry, and development stopped until the spring of 1905.

Wells were drilled on the Clemens, Counselman, Wharton farms, but proved dry, as also the Carter Oil Company well on the Hindman farm on Pierce run. The result of the work of 1902-3 was three pumping wells, two on the Underwood and one on the Counselman farms, with a probable production of 45 barrels daily.

In the summer of 1904 the Waddle-Fisher Company drilled a 20-barrel well on the Abraham Bowman farm three miles southeast of Wellsburg. The second well yielded 15 barrels, but the third and fourth wells on the Hukill and Crouch farms were

dusters. The Kenyon Oil Company of Steubenville, Ohio drilled a 30-barrel well on the Carmichael farm about January 1, 1905, which started renewed activity in the field.

The Carter Oil Company brought in the Bowman No. 1, on a line with the Carmichael and Underwood wells, then followed the Carmichael No. 2 with 60 barrels, Crouch No. 1 with 30 barrels, Byrnes No. 1 with 65 barrels. The Carmichael No. 3 made 160 barrels when drilled, and increased to 258 barrels on the first day's run after being shot. No. 4, two miles and a half southeast of Wellsburg, produced 150 barrels. The Lewis well, just north of the last, made 172 barrels the first day after shooting.

At the close of 1905 there were 13 producing wells out of a total of 15 drilled during 1904 and 1905, and the daily production of the field was estimated at 550 barrels. During the year 1906 a number of good wells were brought in at the northern end of this developed area, and the field appears to be widening out in this direction.

This oil field is peculiar in its shape, being a long narrow belt extending from the Underwood farm to four miles nearly north, and the limit in that direction is not yet determined. On each side of the narrow area there are apparently dry streaks. At the present time this is the only developed oil or gas locality in Brooke county.

The following record of the Barclay well, drilled in 1882 at the mouth of Buffalo creek, is taken from Volume I (p. 368) of the Survey reports. Dr. I. C. White, in this report states that, "This well begins on the first bottom of the Ohio river, 120 feet below the Crinoidal limestone and about 350 feet below the Pittsburg coal, which crops in the highest summits, thus making the interval 1,650 feet between the Berea gas sand and that coal bed."

W. C. Barclay Well No. 1, Wellsburg.

	Feet.		Feet.
Yellow clay.... 20 Blue clay...... 20 Gravel......... 32 } Drive pipe (gas at 43)	72	to	72
Sandstone, blue	6	"	78
Slate, black (gas at 100 feet)	35	"	113
Fire clay	22	"	135
Sandstone, white	12	"	147
Fire clay	40	"	187
Slate	12	"	199
Coal (Wellsburg shaft seam)	5	"	204
Fire clay (cased 208 feet)	10	"	214
Slate (cased 225 feet)	20	"	234
Slate and shale	40	"	274
Sand, white (gas at 287 feet)	40	"	314
Slate and shale (cased 300 feet)	74	"	388
Sand (gas at 400 feet)	15	"	403
Slate and shale (cased 410 feet)	75	"	478
Pottsville "Salt Sand" { Sand, white, salt water, (gas at 535 ft.... 75 Sand, gray.... 30 Sand, blue.... 40 Coal.... 6	151	"	629
Slate and shale	31	"	660
"Big Injun" sand, white (gas and salt water 750 feet, cased at 77 feet)	140	"	800
Slate and shale	50	"	850
"Squaw" sand, white (salt water 850 feet, gas at 875 feet.	50	"	900
Shale, blue	400	"	1,300
Sand, white, gas, Berea (?)	10	"	1,310

"At 1,310 feet struck flow of gas so strong as to prevent further drilling."

The southern end of the Wellsburg pool is four miles southeast of town, on Buffalo creek, centering on the Underwood farm. The Carter Oil Company has furnished the Survey with a number of records of these wells which are of interest.

The F. H. McCord No. 1 well is located one-half mile up Kimlin run and three miles and a half northwest of Bethany. The top of the well is 45 feet below the Pittsburg coal, and its record is as follows:

F. H. McCord Well No. 1.

	Feet.
Coal (5 feet) Lower Freeport	540
Salt sand	765
Big Injun sand	1,155
Berea Grit	1,650
Total depth	1,675

This coal, 585 feet below the Pittsburg, is about the horizon of the Lower Freeport and probably represents that coal. The interval between the Pittsburg and Lower Freeport coals at the Wellsburg shaft is 582 feet. The Salt sand is 225 feet lower, which would bring the horizon in the upper part of the Pottsville. The Big Injun is 1,200 feet below the Pittsburg, which is one hundred (100) feet greater than the interval in the southern part of Ohio county; but the Berea, 1,720 feet below the Pittsburg, agrees closely in this interval with the wells in Ohio county.

The three wells on the W. F. Counselman farm are located opposite the mouth of Mingo run. The Pittsburg coal outcrops about 90 feet above these wells.

W. F. Counselman Well No. 1.

	Feet.
Coal (4 feet) Mahoning	310
Salt sand	667
Limestone, hard	935
Big Injun sand	985
Berea Grit	1,499
Total depth	1,530

Gas and oil on top of Berea, while Nos. 2 and 3 were dry.

W. F. Counselman Well No. 2.

	Feet.
Coal (4 feet) Lower Freeport	430
Salt sand	666
Big Injun sand	980
Berea Grit	1,488
Total depth	1,592

W. F. Counselman Well No. 3.

	Feet.
Coal (4 feet) Lower Freeport	480
Salt sand	725
Big Injun sand	1,065
Berea grit	1,557
Total	1,628

The four foot coal in wells Nos. 2 and 3, 520 and 570 feet below the Pittsburg, shows a shorter interval than in the McCord well (585 feet), but the horizon agrees better with the Lower Freeport than any other seam. In well No. 1 the coal is 400 feet below the Pittsburg, but the salt sand and Big Injun are nearly the same as in the other wells. This would be about the horizon of the Mahoning coal.

The McCleary well No. 1 is located one mile up Mingo run, and the top of the well is 80 feet below the Pittsburg coal. This well, drilled by the Carter Oil Company near the close of 1902, was dry, and the following record has been preserved:

McCleary & Company Well No. 1.

	Feet.
Coal (5 feet) Lower Freeport	495
Salt sand	695
Big Injun sand	1,116
Total depth	2,273

The coal at 495 feet, or 575 feet below the Pittsburg, corresponds to the Lower Freeport at 585 feet below that seam in the McCord and 570 feet in the Counselman well No. 3.

The Adda Hindman well is located two miles and a half northeast of Bethany and one mile up Pierce run. It was drilled by the Carter Oil Company in June, 1903, but proved dry. Its level is 140 feet below the Pittsburg coal. The coal in this well would be 690 feet below that seam, or about 105 feet below the Lower Freeport horizon, which would place it in the Kittanning coal group.

Adda Hindman Well.

	Feet.
Coal (10 feet) Kittanning	550
Salt sand	750
Big Injun sand	995
Berea grit	1,500
Total depth	1,577

The J. A. Crouch well No. 1 of the Carter Oil Company, two miles west of Bethany, is 95 feet below the Pittsburg coal.

J. A. Crouch Well No. 1.

	Thickness. Feet.	Depth. Feet.
Cow Run sand	45	520
Salt sand	85	755
Limestone	20	910
Keener sand	115	930
Big Injun sand	142	1,051
Berea grit	20	1,537
Oil at 1,538 feet (pay sand 5 feet).		
Total depth		1,562

The driller of this well kept a detailed log of this well down to the salt sand at 755 feet, which is as follows:

Log of J. A. Crouch Well No. 1.

	Thickness. Feet.	Depth. Feet.
Sandstone and gravel	24	24
Ten inch casing at		36
Shale	10	34
Sandstone	60.	44
Shale	3	97
Coal, Elk Lick	2	99
Fire clay	3	102
Limestone	5	107
Shale	102	209
Salt sand	56	265
Shale	5	270
Coal, Bakerstown (?)	3	273
Fire clay	3	276
Sandstone, buff	27	303
Shale	10	313
Sandstone	10	323
Shale	75	398
Sandstone	30	428
Coal, Lower Freeport	4	448
Shale	36	520
Salt sand	45	565
Coal, Middle Kittanning	3	568
Shale	52	620
Coal, Lower Kittanning	3	623
Shale	62	685
Black slate	12	697
Coal, Clarion	3	700
Slate	55	755
Salt sand.		

The first coal in this record at 99 feet would be 194 feet below the Pittsburg coal, and is just below a massive sandstone, probably the Morgantown, which would bring this coal at the Elk Lick horizon. The second coal is 365 feet below the Pittsburg, or 171 feet below the first coal, which would come near the Bakerstown horizon.

The coal at 484 feet is 579 feet below the Pittsburg, which corresponds to the distance to the Lower Freeport coal in the McCord and Counselman wells. The next coal is 80 feet lower and would be near the Middle Kittanning coal horizon. The interval of 52 feet to the next coal is large for the Lower Kittanning coal, but it is probably this seam. The coal at 700 feet, or 74 feet below the last, would correspond to the Clarion.

This log, with its various coal seams, is one of the most complete in the Pan Handle area and gives evidence of a wide distribution of these coals. The Lower Freeport coal is recorded in most of the wells of Brooke county, and with good thickness. The other coals are not given in most of the records, but the Crouch log shows they still persist in this area.

The J. T. Bowman well No. 1, of the same company, is a short distance from the last and 75 feet below the Pittsburg coal.

J. T. Bowman Well No. 1.

	Thickness. Feet.	Depth. Feet.
Cow Run sand	55	611
Salt sand	130	790
Limestone	35	850
Keener sand	120	885
Big Injun sand	165	1,025
Berea grit	20	1,520
Oil at 1,524 feet (pay sand 4 feet).		
Total depth		1,546

The Berea grit in this well is 1,575 feet below the Pittsburg, 1,612 feet in the Crouch well, 1,640 feet in the Hindman, 1,589 feet in Counselman No. 1, and 1,647 feet in Counselman No. 3.

The following records of the Underwood wells on Buffalo creek, three miles and a half southeast of Wellsburg, are given in Volume I-a of the West Virginia Geological Survey (p. 232) on the authority of the Carter Oil Company.

Dr. I. C. White states in the above report that, "The Pittsburg coal is opened in the hills here about 200 feet above the derrick floor, thus making the interval from it to the *Berea* of the well 1,700 feet, and from the same coal to the top of the Big Injun Sand 1,200 feet, or practically the same as at Washington, Pennsylvania, where the interval from the Pittsburg coal to the Gantz Sand is 1,800 feet. The record of the Underwood well would point to the conclusion that the Berea of this well may possibly be identical with the Gantz Sand of Washington county."

Robert Underwood Well No. 1.

On Buffalo creek, two miles below Bethany.

	Feet.	Feet.
Coal	260	264
Coal (probably Upper Kittanning)	440	445
Salt sand	650	900
Big lime	920	980
Big Injun sand	980	1,120
Berea grit	1,488	1,507
Total depth		1,509

"Oil and gas in top of Berea," about 30-barrel well.

Robert Underwood Well No. 2.

On Buffalo creek, about 500 feet northeast of No. 1.

	Feet.	Feet.
Coal	308	312
Salt sand (water at 760)	660	980
Big Injun sand, hard	985	1,150
Berea grit, oil in top	1,497	1,515
Total depth	1,546	

(Five-barrel well).

OIL AND GAS IN HANCOCK COUNTY.

The following paragraphs and well records are taken from the oil and gas report of Dr. I. C. White, forming Volume I-a of the West Virginia Geological Survey (pp. 233-237):

"Hancock county lies directly north from Brooke, and has long had some gas and oil production from the 'Berea Grit' of the Ohio Series. This county has the distinction of being the first one in the country to utilize natural gas for the manufacture of carbon black, a gas well in New Cumberland having been used for that purpose as early as 1864, and continued until the gas was practically exhausted in 1883. This gas occurs in the Berea Grit Sand, about 1,500 to 1,550 feet below the Pittsburg coal, in what appears to correspond to the Butler county, Pa., 'Gas Sand,' and to what some of the drillers in West Virginia have frequently termed the upper 'Thirty-foot Sand.' The writer has sometimes thought it possible that this 'Berea' of Ohio might represent the Gantz Sand of Pennsylvania and West Virginia, which underlies the Pittsburg coal by an interval of 1,800 to 1,900 feet, the

measures having thinned away 250 to 300 feet in passing westward to Brooke and Hancock counties, but as this region is directly in the trend of the measures southwestward from Butler county, Pa., where the 'Gas' Sand of that region is found at the same interval (1,500 to 1,600 feet) below the Pittsburg coal, it appears very probable that in Hancock and Brooke counties, at least, the oil sand known as the 'Berea' may represent the latter stratum rather than the Gantz oil sand.

"The 'Turkey-Foot' oil pool of Hancock county was discovered by the Bridgewater Gas Company on the waters of King creek by a well drilled to the Berea, or Smiths Ferry Sand, on the Brice farm, October 12, 1888. No large producers have yet been found, the wells averaging from five to thirty barrels, but there has been a steady and profitable production ever since the field was first opened, and new wells continue to be drilled. The oil is a beautiful light amber in color, like that at Smiths Ferry, Ohio, and about 49° gravity.

"The well records in Hancock are quite lacking in details, and hence do not give much desirable information as to the different members of the formations above the Berea, except that the position of the Big Injun Sand is generally noted, because the casing must go through the latter formation in order to shut off the salt water.

"The Fisher Oil Company of Pittsburg, Pa., has drilled several wells along the waters of Kings creek in the Turkey-Foot field, and the following are some of the records kindly furnished by that company":

Levi Gardner Well No. 2.

	Feet.
Drive pipe (7⅝ inches)	115
Casing (5⅝ inches)	890
Oil sand (Berea)	1,259
Finished at	1,296

Levi Gardner Well No. 3.

	Feet.
Casing, 7 1-5 inches	112
Casing, 5⅝ inches	936
Oil sand, 22 thick	1,259
Bottom	1,281

James Chambers Well No. 1.

	Feet.
Drive pipe, 7⅝ inches	126
Casing, 5⅝ inches	890
Oil sand	1,212
Through oil sand (Berea)	1,236
Bottom	1,240

James Chambers Well No. 2.

	Feet.
Drive pipe, 7⅝ inches	126
Casing, 5⅝ inches	916
Oil sand	1,185
Through sand	1,208
Finished at	1,223

Thomas Peterson Well No. 2.

	Feet.
Drive pipe, 7⅝ inches	95
Casing pipe, 5⅝ inches	820
Oil sand	1,167
Through oil sand (Berea)	1,189
Finished at	1,201

Mercer Well No. 1.

	Feet.
Casing, 7⅝ inches	140
Casing, 5⅝ inches	848
Oil sand (Berea)	1,200
Through sand	1,218
Bottom	1,238

Mrs. Wylie Well No. 1.

	Feet.
Casing, 7⅝ inches	99
Casing, 5⅝ inches	916
Oil sand (Berea)	1,234
Bottom of sand	1,257
Bottom of well	1,272

Mr. James Murray and Murray and Miller of Chester, Hancock county, have operated to a considerable extent for oil in the Turkey-Foot field, and they have furnished the Survey the following records:

S. A. Richmond Well No. 3.

Four and one-half miles southeast of Chester. Authority, James Murray.

	Feet.	Feet.
Coal (probably Middle Kittanning)	350	
"Big" coal (probably Lower Kittanning)	410	
Salt sand	514	
Big Injun sand	740 to	767
Berea grit	1,113 to	1,160

"Five-barrel well."

S. A. Richmond Well No. 4.

Four and one-half miles southeast of Chester. Authority, James Murray.

	Feet.	Feet.
Coal (Mahoning?)	325	
"Big" coal (Lower Kittanning?)	520	
Salt sand	610	
Bottom of Big Injun sand	883	
Berea sand to bottom of well	1,212 to	1,254

"Five-barrel well."

J. W. Patterson Well No. 1.

Four and one-half miles southeast of Chester. Authority, James Murray.

	Feet.	Feet.
"Big" coal (Upper Kittanning?)	325	
Salt sand	465 to	510
Bottom of Big Injun sand	760	
Berea sand to bottom of well	1,070 to	1,107

"Show of oil in Berea."

Robert Stewart Well No. 1.

Five miles southeast of Chester. Authority, James Murray.

	Feet.	Feet.
"Big" coal (Lower Kittanning)	318	
Salt sand	420 to	490
Big Injun sand	680 to	720
Berea grit to bottom of well	1,056 to	1,090

"Fair gas well in Berea."

W. N. Bell Well No. 1.

Seven miles southeast of Chester. Authority, Murray & Miller.

	Feet.
Bottom of "Injun"	1,030
Top Berea sand	1,325
Total depth	1,359

"The Bell wells made about 25 barrels when first drilled."

W. N. Bell Well No. 2.

Seven miles southeast of Chester. Authority, Murray & Miller.

	Feet.
Bottom of "Injun" sand	955
Top of Berea sand ("pay," 1310′ to 1320′)	1,296
Total depth	1,327

"Made about 25 barrels at first."

W. N. Bell Well No. 4.

Seven miles southeast of Chester. Authority, Murray & Miller.

	Feet.		Feet.
Bottom of Big Injun sand	900		
Berea sand	1,253	to	1,280
Total depth of well	2,266		

"Made about 25 barrels at first."

H. L. Patterson Well No. 1.

Seven miles southeast of Chester. Authority, James Murray.

	Feet.		Feet.
Coal (Mahoning, "Groff" vein)	200		
Coal (Lower Freeport, "Roger" vein)	340		
Sandstone (Freeport)	370		
"Big" coal (Lower Kittanning)	450		
Salt sand	560	to	610
Big Injun sand	844	to	876
Berea grit	1,183	to	1,210

Robert Patterson Well No. 1.

Near Hollidays Cove. Authority, James Murray.

	Feet.		Feet.
Coal (Bakerstown?)	90		
"Big" coal (Lower Freeport, "Roger" vein)	350		
Big Injun sand	720	to	910
Berea sand	1,240	to	1,276
Total depth	1,296		

"Dry hole."

"In the region of Smith's Ferry, Ohio, just opposite the northern point of Hancock county, where the Berea Sand has produced oil for many years, its interval below the Lower Kittanning coal is 750 feet, and below the Ferriferous (Vanport) limestone, 700 feet, while in Butler county, Pa., the interval from the Ferriferous Limestone to the top of the Gantz, or "Hundred-foot," is 950 to 1,000 feet. In the same county (Butler) the interval from the Ferriferous Limestone to the "Gas" Sand is 750 to 800 feet, and hence it appears more probable that the "Berea," or producing sand of Hancock county, will prove to be identical rather with the "Gas" Sand of Butler, than with the Gantz (upper division of the Hundred-foot)."

The preceding well records in Hancock county as given by Dr. White are incomplete, and it is unfortunate that nearly all the available records are so incomplete.

Mr. Charles Foss of New Cumberland, who has drilled many wells in Hancock county to the east and southeast of New Cumberland has furnished the Survey with the following additional records.

The Smith No. 1 on the Smith farm three miles and a half up Kings creek, and four miles southeast of New Cumberland, produced 200 barrels a day when first drilled.

Smith Well No. 1.

	Feet.
Bottom of Big Injun sand	693
Top of Berea sand	1,043
Bottom of Berea sand	1,070

Smith Well No. 20.

One thousand feet from No. 1.

	Feet.
Top of salt sand	320
Bottom of salt sand	380
Top of Berea sand	1,011

Smith Well No. 42.

	Feet.
Cased to	787
Top of Berea sand	1,384
Bottom of Berea sand	1,394
Finished at	1,424

This was the deepest well on this farm and one of the deep wells of the field.

The following records are of wells drilled in this same area:

Cable Well No. 12.

	Feet.
Cased	725
Top of Berea sand	1,321
Bottom of Berea sand	1,333
Finished	1,371

This was the deepest well on Cable farm and produced 25 barrels when drilled, and now yields two barrels daily.

Lee Well No. 13.

	Feet.
Cased	800
Top of Berea sand	1,413
Bottom of Berea sand	1,423
Finished	1,437½

This well was drilled in the old field, which gave but few barrels daily production, but the No. 13 well started with 18 barrels a day.

Brice Well No. 1.

	Feet.
Top of Berea sand	975
Bottom of Berea sand	995
Finished	1,009

This well is the original well of the field. The first well was pulled out and Brice No. 1 was drilled on October 16, 1888, with

a daily production of 100 barrels and resulted in the rapid development of the Turkey-Foot oil field on Kings creek, two miles east of the river. This well at the present time, after 18 years' use, is producing about one barrel a day.

The early wells on the Smith farm were drilled 16 years ago. Smith No. 1 is said to have produced $100,000 worth of oil. These old wells now yield one or two barrels daily.

The development on the North fork of Kings creek has taken place in the last seven years. There are some 40 wells on the Smith and Cable farms. A few of these started with 100 to 250 barrels production. Some of the new wells in this section start now with 30 barrels, but the average daily yield of the older wells is one to two barrels.

Morrow Well No. 1.

	Feet.
Cased	515
Top of Berea sand	1,085
Bottom of Berea sand	1,100
Finished	1,135

Sindorf Well No. 1.

	Feet.
Cased	545
Hurry-up sand	755
Top of Berea	1,105
Bottom of Berea	1,115
Finished	1,138

Well produced 6 barrels at first.

The Sutton Brothers have drilled over a large area east of New Cumberland, and have 25 or more oil wells at the present time. The Carson and Freshwater pools at the head of Hardin run and near the State line were opened about twelve years ago by wells producing 30 barrels daily. Renewed activity in this field came in 1902, and a large number of wells were drilled. The depth to the Berea sand is 1,350 to 1,500 feet and the wells yield two to three barrels each daily.

During the past two years active prospecting work has been carried on in search of oil and gas in the northern portion of Hancock county. A number of good wells have been struck on Tomlinson run and north along the various streams which flow into this run. This whole area is now attracting much attention and several drilling rigs are at work. The wells have been average

producers of ten to twenty barrels, but recent wells on the Brenerman farm near Arroyo produced 200 barrels when drilled.

South of Chester and along Mercer run the sand is gas bearing, and these wells furnish a supply of fuel to the farmers of the area and to the town of Chester. This field was opened about 1904. The depth to the Berea sand at Chester is 528 feet.

Mr. Ed. Stewart, who has drilled many of the wells in this northern area has furnished the following records.

H. B. Moore Well No. 2, Mercer Run.

Located up Mercer run three-quarters mile. Gas well with 245 pounds rock pressure.

	Thickness. Feet.	Depth. Feet.
Clay	5	
Sandstone	30	35
Slate	65	100
Sandstone	50	150
Slate and lime	160	310
Salt sand	40	354
Slate	130	484
Big Injun sand	40	524
Slate and blue rock	250	774
Black slate	43	817
Berea sand	13	830

The Bennett well is located near the Moore well and had an original rock pressure of 325 pounds. Its pressure at the present time is 201 pounds.

Bennett Well, Mercer Run.

	Thickness. Feet.	Depth. Feet.
Clay and loose rock	10	
Slate	90	100
Sandstone	135	235
Slate and lime	180	415
Salt sand	40	455
Slate	130	585
Big Injun sand	40	625
Slate and blue rock	260	885
Black slate	41	926
Berea sand	16	942

Plate XIII.—Oil Wells in the Carson-Freshwater Pool, Near Head of Hardin Run, Hancock County.

The Stewart Brothers of Chester drilled a well three-fourths mile east of mouth of Mercer run and a half mile north of North fork of Tomlinson run, on the Ed. Murray farm. This well was completed September 12, 1906, and Mr. Ed. Stewart kindly kept a record of the well for this report. The well gave a gas pressure of 26 pounds through the two-inch tubing.

Ed. Murray Well No. 1, North Fork Tomlinson Run.

	Thickness. Feet.	Total Depth. Feet.
Clay	10	
Slate	25	35
Sandstone	25	60
Slate	12	72
Coal, Mahoning	3	75
Slate	60	135
Sandstone	45	180
Coal, Lower Freeport	4	184
Fire clay	6	190
Slate, limestone, shells	40	230
Slate	95	325
Salt sand	105	430
Black slate	105	535
Big Injun sand	40	575
Slate and lime	260	835
Black slate	43	878
Berea sand	19	897

The derrick floor at this well is 1,040 feet above mean tide and is 60 feet by barometer above an old abandoned coal mine correlated with the Mahoning coal. The coal at 75 feet would be the same coal as in the old mine, and the coal at 180 feet would be the Lower Freeport.

Late in the fall of 1906 E. W. Marland & Company brought in a 100-barrel oil well one-half mile north of Dry run and one mile north of Arroyo, in the northwestern part of Hancock county. The following record of this well has been given by Mr. E. W. Marland:

E. W. Marland Well No. 1, Dry Run.

	Thickness Feet.	Depth. Feet.
Gravel	15	
Shale	20	35
Coal, Lower Kittanning	3	38
Fire clay	8	46
Shale and conglomerate	50	96
Sandstone, red and hard	54	150
Coal, Clarion	5	155
Fire clay	2	157
Slate	68	225
Coal, Mercer?	6	231
Unrecorded	94	325
Black shale with coal	15	340
Unrecorded	160	500
Big Injun sand (some gas)	22	522
Unrecorded	40	562
Squaw sand (some black oil)	2	564
Unrecorded	166	730
Berea sandstone (top)		730
Oil at		738
Finished		747

This well made 200 barrels for nearly a week; 125 barrels the second week, 100 barrels the third week, and 75 barrels the fourth week.

The derrick floor is a little below the level of an old coal opening a short distance north, where the coal is two feet six inches thick and corresponds to the Middle Kittanning horizon. This would make the first coal in the well with its underlying fire clay, Lower Kittanning. The coal at 150 feet would be the Clarion, while the next coal at 225 feet would probably belong in the Mercer group. During December, 1906, two more wells were drilled in the locality and made 200 to 250 barrels.

CHAPTER X.

CLAYS AND OTHER MINERAL RESOURCES OF THE PAN HANDLE COUNTIES.

THE CLAY AND CLAY INDUSTRY OF THE PAN HANDLE COUNTIES.

Ohio and Brooke Counties.

A general review of the clay industry in West Virginia, with a discussion of the origin, physical and chemical properties of clays, their classification and uses may be found in Volume III of the reports of the West Virginia Geological Survey.

At the present time there is not one brick or tile plant in Ohio or Brooke counties, and all such material used must be shipped in from other sections of the State or from other States. There have been in past years a few small hand mold brickyards which used surface clays or weathered shales. They were located here and there, but only persisted in the work for a few seasons and then were abandoned. Some years ago a machine mold plant was in operation near Mont de Chantal, near Wheeling. The shales below the Pittsburg coal were used, and the coal mined for fuel, but the work has been abandoned and the machinery removed.

There are many places in the two counties where the shales could be used for brick manufacture. Along the National road near Wheeling and Elm Grove are good deposits of such shales, and also up the various small tributary runs of Wheeling creek and the Ohio river. Three of these shale outcrops were analyzed in the Survey laboratory and are of good quality. Many other deposits could be selected of equal value, but these were selected to show the character of the shales, and were available for use.

The shales below the Pittsburg coal, the shales near the Sewickley coal, and the Pittsburg red shales are available in Brooke county. The last group is used in Monongalia county by the Morgantown Brick Company, at Huntington by the Ohio Valley Clay Shingle Company in manufacture of roofing tile.

There are no deposits of fire clay near the surface in the two counties, but deep wells show the existence of the fire clays, which are used near New Cumberland. These clays could be mined in deep shafts, a method too expensive to be practical at the present time unless worked in connection with the coal over the clay.

On the hill back of the Reymann brewery in East Wheeling, Ohio county, there is a fine outcrop of 20 feet or more of shales just below the Sewickley coal, which might be used for brick manufacture. This shale has the following chemical composition:

Analysis of Sewickley Shale, East Wheeling.

	Per cent.
Silica	60.40
Alumina	22.05
Ferric iron	2.55
Ferrous iron	1.35
Magnesium	1.01
Lime	1.40
Sodium	0.85
Potassium	1.82
Water	2.10
Titanium	0.14
Phosphorus	not. det.
Loss on ignition	6.40
	100.07

One mile and a half up George run from South Wheeling 50 feet of buff shales are exposed on the farm road to the north, and were used in the manufacture of brick at a small yard at the north end of this road some 15 years ago. The Benwood limestone forms the bed of the run just below these shales. The chemical composition of the shale is shown by the following analysis:

Analysis of Shale Above Benwood Limestone, George Run.

	Per cent.
Silica	59.20
Alumina	23.55
Ferric iron	1.65
Ferrous iron	1.08
Magnesium	1.30
Lime	2.20
Sodium	0.19
Potassium	1.11
Water	2.10
Titanium	0.15
Loss on ignition	7.70
	100.23

One-half mile southeast of Elm Grove, past the county hospital, 15 to 20 feet of shales are exposed below the Sewickley coal. These shales have the following composition:

Sewickley Shales Near Elm Grove, Ohio County.

	Per cent.
Silica	58.90
Alumina	19.00
Ferric iron	3.30
Ferrous iron	2.16
Magnesium	1.70
Lime	0.90
Sodium	1.44
Potassium	0.87
Water	2.30
Titanium	0.32
Loss on ignition	8.85
	99.74

White Ware Potteries at Wheeling, in Ohio County.

The presence of valuable gas and coal fuel, the nearness to large markets and excellent transportation facilities have located one of the greatest white ware pottery centers in this country in the Upper Ohio valley, in Ohio and West Virginia. The present output of the potteries of this State amounts to over a million dollars a year, over one-half the total value of the clay industry of the State. West Virginia now holds fifth rank in this industry.

Wheeling has long been prominent in the pottery industry with large plants devoted to the manufacture of a high grade and ornamental product. These plants are now controlled by two companies.

Warwick Pottery Company.—The plant of this company is located in the city of Wheeling and was established in 1887. The ware is burned in seven bisque and glost kilns, and in seven decorating kilns. While the company manufactures dinner and toilet ware, they make a specialty of ornaments and novelties.

Wheeling Potteries Company.—The first white ware pottery in West Virginia was started at Wheeling in 1879, a second was started in 1889, and a third in North Wheeling in 1890; and in 1905 these plants were combined under the name of Wheeling Potteries Company.

Two of these plants south of Wheeling creek are devoted to the manufacture of table and toilet ware and novelties. They have 22 bisque and glost kilns and 20 decorating kilns. The North Wheeling plant of five kilns is engaged in the manufacture of sanitary ware, plumbers' ware and the like.

HANCOCK COUNTY.

Potteries.

The white ware china industry in Hancock county centers at Chester and Newell, with one plant at New Cumberland.

New Cumberland.—The Chelsea China Company built a pottery of six kilns at the lower edge of New Cumberland in 1889 for the manufacture of white china and decorated ware. This plant was partially destroyed by fire in January, 1904. In the spring of 1905 the property was purchased by the Standard Porcelain Company, composed mainly of local stockholders. Two kilns are in use and the plant is engaged in the manufacture of electrical supplies.

Chester.—The plant of the Edwin M. Knowles China Company is located at the upper end of the town of Chester, which is across the Ohio river from East Liverpool, Ohio. The plant was established in 1900 for the manufacture of semi-vitreous dinner and toilet ware, both plain and decorated.

The plant is equipped with a complete line of pottery machinery, including two blungers, agitators, screens, two filter presses, pug mill, jollys, lathes, etc. The ware is burned in three bisque kilns, 18½ feet in diameter; three glost kilns, 16½ feet in diameter, and the decorated ware in four decorating kilns. The annual output amounts to $200,000 a year.

The Taylor, Smith & Taylor pottery is located nearly opposite the Pennsylvania railroad station in Chester, and was built in 1890. The equipment includes three blungers, screens, agitators, two filter presses, jollys, lathes, etc. The ware is burned in four bisque kilns, 18 feet in diameter; five glost kilns, 16 feet in diameter, and the decorated ware is burned in six decorating kilns. About 300 people are employed and the annual sales amount to $300,000. The ware is semi-vitreous porcelain dinner and toilet sets and novelties.

Newell.—The town of Newell was platted in 1905 around the site of the new pottery of the Homer Laughlin China Company. This plant has been under construction for nearly a year and is now practically completed. This is probably the largest single pottery in the world.

The buildings are of brick, well lighted and ventilated. The factory covers a space 290 by 600 feet, the power plant is 40 by 134 feet, while the two-story office building is 64 by 64 feet. The buildings thus cover 183,456 square feet, and the total floor space is 420,000 square feet, including the five-story warehouse.

The equipment includes eight double and two single blungers, 40 jolly wheels, 12 lathes, etc., operated by electricity. There are 13 bisque kilns 18 feet in diameter, 17 glost kilns 16½ feet in diameter, or a total of 44 kilns fired with natural gas. The pottery completed cost $500,000 and will employ 1,000 to 1,200 people. It will be devoted to the manufacture of practically one kind of ware, semi-porcelain table and toilet ware.

The Clay and Brick Industry in Hancock County.

The largest clay and brick center in West Virginia is at New Cumberland, where the Clarion and Lower Kittanning clays are used for the manufacture of building brick and paving blocks, and the Clarion clays for sewer pipe.[1] The shales between these clays were formerly burned into common brick.

The town of New Cumberland was not established until 1839, but clay was shipped from this section, at mouth of Holberts run in 1830 and taken to Pittsburg, where it was used for brick manufacture. Two years later the first brick plant was erected. In the next twelve years five plants were in operation. The output increased from 200,000 brick in 1837 to 1,500,000 in 1844, and 11,000,000 in 1872, in addition to 12,000 tons of fire clay shipped to points on the Ohio river. The first gas well was struck in this section in 1862, and in 1876 was used for burning brick at the Clifton plant. This is probably the earliest date that gas fuel was used in brick works.

1. An error was made by the writer in the identification of the lower clay at New Cumberland in the preparation of Volume III of the reports of this Survey. The clay described in that volume as Lower Kittanning at New Cumberland is Clarion, and the one called Middle Kittanning is Lower Kittanning. The cause of this error is given under the discussion of these horizons in Chapter VI of this volume.

Standard Fire Brick Company.—The original plant of this Pittsburg company was erected by David Troup in 1874, and is located at the side of the Pennsylvania railroad track two and one-half miles north of New Cumberland station, at a point called Globe.

The clay from the bank above the mill is broken in a Blake crusher and then finely ground in two nine-foot Stevenson dry pans, tempered in a twelve-foot pug mill and molded in a Bonnot stiff-mud auger machine with a capacity of 60,000 brick a day.

The brick are dried in an eight-track hot air tunnel drier, which has a capacity of 55,000, and burned with coal in seven 28-foot and four 30-foot kilns, holding 55,000 and 60,000 brick. The brick are buff in color. This plant also grinds 200 to 300 tons of clay a month, and ships the product to the steel works at Pittsburg.

Rocky Side Brick Plant.—This plant was built by Evans & Shane in 1870, and is now owned, with a number of other plants below, by the Mack Manufacturing Company of Philadelphia, which bought the property and formed the consolidation of these plants in January, 1894. The plant is one-half mile below the Globe works of the Standard Fire Brick Company. The clay is brought from the mines above the plant, ground in three-nine-foot dry pans, tempered in pug mill, and molded in a Freese auger machine with a capacity of 60,000 brick in ten hours.

The brick are dried in a nine-track tunnel drier and burned in ten Eu Daly down-draft kilns and two round down-draft kilns, 28 feet in diameter, holding 34,000 paving blocks or 62,000 standard size brick. The brick are buff color, made 8⅜ by 4 by 2½ inches for standard size brick, and 9¼ by 3⅛ by 4 inches in the blocks, which weigh 9¼ pounds. On demand the brick are re-pressed on a Richardson machine.

Union Brick Plant of Mack Company.—The Union plant is located about one-quarter mile below the last, and was started in 1868 by Thomas Manypenny. The equipment is similar to that in the Rocky Side plant. There are seven Eu Daly kilns and four of home construction.

Eagle Sewer Pipe Plant of Mack Company.—The Eagle plant is about 1,000 feet below the Union and was started as a brick plant in 1870 by Manypenny & Cuppy.

The clay used was from the Clarion bed, mined close to the plant. It was crushed in a nine-foot dry pan and same size wet pan, and molded in a Turner Vaughn and Taylor press, with 44-inch steam cylinder and 20-inch clay cylinder capable of making pipe from 2 to 24 inches in diameter. The pipe were dried on three slat floors, one above the other, heated by steam, and burned in eleven circular down-draft kilns, 28 and 30 feet in diameter. The plant has not been operated since 1902. A photograph of this plant is given in plate XV.

Etna Brick Plant of Mack Company.—The Etna plant is 1,200 feet below the Eagle works and is one of the oldest plants in the State. It was started in 1844 by Thomas Freeman. There are two nine-foot dry pans, a twelve-foot pug mill, a Freese auger machine of 50,000 brick capacity, a ten-track tunnel drier, and eight down-draft circular kilns 28 feet in diameter. The upper part of plate XV shows the two clays and hoisting building at this plant.

Crescent Brick Plant of Mack Company.—The Crescent plant is nearly three-quarters of a mile below the Etna and was started in 1856 by Atkinson & Garlick. It has 50,000 brick capacity, with similar equipment to the Etna, and has eleven kilns, illustrated in upper part of plate XVI.

Clifton Sewer Pipe Plant of Mack Company.—The Clifton plant is at the side of the Crescent and is another early yard, started in 1844 by McCoy & Shawl. The equipment consists of a wet pan, three dry floors, a Means press with 40-inch steam cylinder and 18-inch clay cylinder. The sewer pipe were burned in twelve kilns, 28 and 30 feet in diameter. The plant has been idle since 1902. A photograph of this plant is given in lower part of plate XVI.

Sligo Sewer Pipe Plant of Mack Company.—The Sligo works are two miles below town, also started as a brick plant in 1844 by James Porter. It is equipped similar to the Clifton plant, with eleven down-draft kilns, and also contains an equipment of brick machinery, but it has not been operated since 1902.

The early brick industry of West Virgina started in this section below New Cumberland, near Kings creek and Holbert run. Remnants of the old kilns of the Kerr & Mahan yard are visible near Holberts run. This plant, built in 1845, and the Freeman plant, built in 1858, at the mouth of the run, still show a few

broken kilns. In 1837 Porter & Beall built a plant below New Cumberland and shipped brick by water to Wheeling and other points on the Ohio. This plant was the property of the Standish Brick Company, and consisted of a large four-story building equipped with brick machinery and eight round down-draft kilns. but the plant has not been operated for some years, and during the past year was dismantled.

Near this plant is the abandoned plant of the Lone Star Brick Works with a small auger machine, a nine-foot dry pan, twelve-arch brick drying floor, and five down-draft kilns. In 1846 two plants were started back of New Cumberland, up Hardin run, but they were soon abandoned. In the same year a plant was started at the north edge of New Cumberland and worked until early '70's, the old stack being still there.

Porter Brick Company.—The Claymont plant of the Porter Company, started by Thomas Freeman in 1834, is located about one mile and a half below New Cumberland. It is built in two sections, the lower one being equipped with a nine-foot dry pan, pug mill, Bucyrus auger machine of 30,000 capacity. The brick are burned in eleven round down-draft kilns, 26 and 28 feet in diameter, holding 50,000 to 60,000 brick each.

The upper building, which is the original Freeman plant, is used for crushing the clay in a Blake crusher, with a capacity of 100 tons a day, and for hand-molded fire brick made in various sizes and shapes. One man makes in a day 4,000 standard size brick, and 75 to 100 boiler slabs used for covering steam boilers. This section is also equipped with a small Raymond auger machine of 25,000 capacity, used with several dies for brick and tile of various special designs. The brick molded by hand or on the special auger machine are dried on the large floor of the building by steam.

West Virginia Fire Clay Manufacturing Company.—This plant is located a mile below New Cumberland and was built in 1896. It is used entirely for crushing clay, which is shipped to Pittsburg and Wheeling. The equipment consists of a Blake crusher and two nine-foot dry pans, giving a capacity of 200 tons of crushed clay a day, though in one special run 293 tons were crushed. The clay is obtained from mines just above the plant, where the flint clay is six and one-half feet thick, covered with

three feet of coal. The entry runs south of east for 800 feet in the old mine, but at that point the sandstone roof dipped down and cut out clay and coal, so a new entry was started below.

American Sewer Pipe Company.—The plant of this company is located a half mile below New Cumberland near the site of the old Black Horse tavern, and was known as the Black Horse works, started in 1844 by James and William Porter. It was purchased by the present company in 1889. Sewer pipe was made here until 1896, when it was again converted into a brick plant, and no pipe has been made since that year.

The brick are molded in a Freese auger machine, which has a daily capacity of 60,000 building brick, or 40,000 paving blocks. The blocks are repressed on two double mold Raymond and two double mold Richardson machines. There are two drying tunnels, with nine tracks each. The clay is mined through an entry 2,300 feet long.

Acme Clay Works.—The Acme, or Chapman plant, is located at the upper end of the town of New Cumberland and used for grinding flint clay for shipment. It was started in 1901 and is equipped with two dry pans having a daily capacity of 100 tons.

Clay Mines.

The railroad track at the Globe plant is about 35 feet above the level of water in the Ohio, and at this level, or a few feet below is the Clarion clay, which is worked in a 20-foot shaft. The upper clay (Lower Kittanning) is 50 to 80 feet higher and is opened by an entry driven east into the hill, which has been worked a distance of 2,000 feet. (Plate XV shows the position of the two clays at the Etna plant). The clay has an average thickness of eight feet, though in a few places it reaches 15 feet and has 30 inches of coal over it, with a cover of 30 to 40 feet of sandstone, which pitches down in the New Cumberland area, forming a roll cutting out the clay here and there.

The clay is hard, breaking with irregular fracture, and bluish-gray in color. It is hauled in mine cars to the tipple and dumped near the plant, where it is left to weather for a time. The weathering action often being hastened by throwing steam and hot water over the piles of clay. The structure of the clay is

similar in all the mines of this area and is shown in the following section at the Rocky Side mine:

	Ft.	in.
Sandstone	40	
Coal	2½	
Flint clay	6	
Gray shale clay	4	
Blue shale clay	12	
Sandstone floor	4	
Fine laminated shales	40	
Coal (Clarion)	0	3
Clay	10	

The bottom clay in this section is the Clarion, as also the coal above it. In working this clay there is considerable trouble with water, and the material has to be elevated to the plant. It is at the present time only used at the Etna and Globe works, but it is claimed to be especially adapted to sewer pipe manufacture, and when the sewer pipe plants were in operation they used this clay in preference to the upper one, but for the past few years very little pipe has been made.

In the manufacture of brick and paving blocks, the flint clay, gray and blue shales are mixed together. These shales are more or less laminated clays of plastic variety, and the color distinction is very slight. The coal and clays belong to the Lower Kittanning series, with the Lower Freeport sandstone roof. The section of the hill above the Rocky Side mine shows the following formations above the mine:

	Feet.
Top of hill with sandstone boulders.	
Sandy shales and thin sandstone	90
Coal (formerly worked), Ohio No. 7	2
Shales	18
Finely weathered shale bed (opened for Bolivar clay, but not found)	20
Shales and thin sandstone	110
Coal (formerly worked), Lower Freeport	2 1-6
Shaly sandstone	90
Level coal and clay mine	40

The Upper Freeport coal appears to be absent in this section. Nearer the town of New Cumberland Dr. I. C. White measured the following section:[1]

	Feet.	Inches.
Fire clay and limestone, Upper Freeport	5	
Concealed and sandstone, massive	40	
Flaggy sandstone and sandy shales	20	
Coal, "Roger" vein, Lower Freeport	3	4
Shales and concealed	30	
Sandstone massive, Lower Freeport	70	
Middle Kittanning coal	2	11
Fire clay and sandy shales	30	
Lower Kittanning coal	3	
Fire clay, Lower Kittanning	8	
Sandy shales and concealed to low water in Ohio river.	50	
Interval, estimated, to top of Pottsville	25	
Total	287	3

At Kings creek, four miles south of New Cumberland, at the Casparis stone quarry, the order of the formations is shown as follows:

	Feet.	Inches.
Shale cover	20	
Coal (Lower Freeport)	1	10
Clay and shale	4	
Sandstone (Lower Freeport)	80	
Coal (Middle Kittanning)	2	10
Fire clay	8	

The Lower Kittanning clay north of New Cumberland in its outcrop along the hill is very nearly level, with its floor 750 feet (determined by transit level) above the sea, dipping at the north from the Union mine (750 feet) to the Rocky Side (732), and rising slightly at the Globe (737) in a distance of about three-fourths mile. For a mile from the Clifton to the Union mine, including the two Crescents, Etna and Eagle mines, the floor of the clay is at the same level, 750 feet.

Traced to the east of Etna mine the clay rises 24 feet in 1,200 feet across the sandstone roll, and the bottom of the sandstone rises 34 feet. The same clay at the mouth of Kings creek is 650 feet above sea, or a dip to the east of south of 100 feet in four miles, 25 feet to the mile, and it passes under the Ohio river three-fourths of a mile below this place.

Sandstone Roll.—The sandstone roof of the coal and clay runs quite uneven, bending down and cutting out part of the lower layers. There appears to be one well-defined roll of sandstone which completely cuts out the clay and coal under it.

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1. W. Va. Geol. Survey, Vol. II, p. 381.

This roll was found in the old mine at Rocky Side at 1,200 feet from the mouth of the entry and work was abandoned after penetrating it 600 feet. The shale remained below the sandstone, but the coal and flint clay were gone. A second entry was made to the north about 1,400 feet, and the roll was found at 100 feet, and a little further south the sandstone roll comes to the edge of the hill, showing some clay below it and bands of coal caught in the layers of sandstone. The new entry of Rocky Side, north of the other entries, runs north of east for 300 feet and the roll has not yet been encountered, but it is found in the Globe mine a short distance north. In the middle Rocky Side mine, south of the entries described above, the roll was struck 730 feet in the entry, further south in Union mine it was found at 1,250 feet, and at the lower Union entry at 1,200 feet.

Deep Gut run bends around back of these mines in a deep ravine and cuts across the sandstone roll, which is there 1,200 feet wide. Approaching the roll from the west, the coal disappears and the clay changes to a sandy shale, which soon pinches out, a sandstone layer below and one above the clay coming together. Nodular and lenticular masses of coal are caught in the sandstone in a number of places in long narrow stringers one and one-half to three inches thick. In one place a mass of coal forms a small core in a large block of sandstone. The lower sandstone bed is broken and wavy in its bedding, forming miniature folds. Some of the sandstone courses are plainly cross bedded.

In one place a foot of sandstone is cross bedded and over it is a few inches of sandstone with numerous small iron concretions and lenses of coal included. Over one of the abandoned entries on this side of the roll there are two feet of black shale, then thirty inches of coal with vertical fracture planes, and much broken, a branch of the coal bending with curved planes down into the black shale, the coal is covered by two feet of sandstone, then thirty inches of shale with the solid sandstone above. At this place the roof dips rapidly to the northwest and 100 feet in the hill cuts out the coal and clay. Both to the east and west of this entry the coal soon disappears. A small block only has been caught in the roll at this point. Farther to the east beyond the roll an entry has been driven into the hill and is following along the east side of the roll, where the coal and clay are present in

normal thickness. A new entry across the ravine is also clear of the roll.

South of town, near Black Horse works, in the entry of the West Virginia Fire Clay Company, the roll was struck at 800 feet and was penetrated 200 feet below and abandoned. The coal and clay were absent below the roll and the shale was very hard. The new entry, about 600 feet east, shows the coal eight or ten feet lower than in the old entry and has not yet encountered the roll.

These measurements would give the general course of the sandstone roll as S. 30 E., but its course is more or less irregular. The presence of this roll might possibly be explained by the assumption that the coal swamp on the border of the former sea was submerged, and as the Freeport sands were deposited over it a strong current had its course across this particular area, cutting out the coal and clay, removing it in large part; later the channel was filled with sand, in part mixed with fragments of the coal, and raised into land, leaving the record of the old current in this sandstone roll.

Chemical Analyses.

The clays selected for analysis were taken from the Clifton and Etna mines, above New Cumberland. In the Clifton mine the Lower Kittanning coal rests on six feet of bluish-gray flint fire clay, and below this are four feet of the gray shale clay with ten to twelve feet of blue shale clay under the gray. In the manufacture of the brick the three varieties are mixed. Their composition is shown by the following analyses:

Clifton Mine, Lower Kittanning Clay and Shales.

	Flint clay.	Gray shale.	Blue shale.
Silica	52.24	57.58	59.76
Alumina	29.28	21.41	22.79
Ferric iron	2.73	3.75	0.60
Ferrous iron	0.51	3.45	3.53
Magnesia	0.20	1.44	1.23
Lime	0.68	0.46	0.59
Sodium	0.37	0.10	0.42
Potassium	2.11	3.14	3.79
Water	1.28	0.38	0.54
Titanium	1.20	0.84	0.82
Phosphorus	0.07	0.11	0.46
Loss on ignition	10.12	7.25	5.26
Total	100.79	99.91	99.79

The following analyses of the Mack Company clays were made by H. A. Wheeler of St. Louis and kindly furnished the Survey by the officers of the Mack Company:

	UNION			CRESCENT	
	Rock	Clay	Shale	Rock	Clay
Ignition loss	8.76	8.93	7.66	8.36	10.87
Silica	55.99	62.92	60.88	55.12	56.84
Alumina	19.03	24.07	19.74	20.67	28.81
Oxidê of iron	10.04	1.39	7.85	9.83	1.76
Lime	0.81	0.48	0.63	0.74	0.28
Magnesia	1.70	0.55	1.48	1.95	0.41
Alkalies	3.42	1.89	2.01	3.46	1.02
Totals	99.75	100.23	100.25	100.13	99.99

	ROCKYSIDE			ETNA		
	Rock	Clay	Shale	Rock	Clay	Loam
Ignition loss	6.17	9.58	6.72	9.84	9.84	6.16
Silica	62.29	60.32	60.28	58.83	59.16	69.86
Alumina	19.32	25.94	20.13	20.27	25.09	15.25
Oxide of iron	6.80	1.24	7.11	7.99	2.93	5.79
Lime	0.42	0.56	0.83	0.56	0.60	0.26
Magnešia	1.84	0.44	1.96	0.69	0.50	0.69
Alkalies	3.30	2.04	2.86	2.10	1.92	1.86
Totals	100.14	100.12	99.89	100.28	100.04	99.87

The term rock in these analyses refers to the shale below the fire clay.

The fusible components reach 12.34 per cent in the gray rock, 10.14 per cent in the blue rock, and 6.59 per cent in the flint clay. The percentages of silica and alumina agree fairly close, in the flint clay 81.52 per cent, in the gray rock 78.99 per cent, in the blue rock 82.55 per cent. The gray rock is high in iron, 7.20 per cent, but the mixture of clays burns buff in color.

A rational analysis of the flint clay would give:

Free silica	26.44	per cent.
Clay substance	76.66	" "
Feldspar	5.90	" "

The mechanical analysis of the same clay gives:

	Range of particles in millimeters.	
Fine clay	0.0 to .001	5.00 per cent.
Coarse clay	.001 to .005	4.6
Silt	.005 to .02	10.6
Fine sand	.02 to .15	9.7
Medium sand	.15 to 1.0	25.9
Coarse sand	1.0 to 4.0	42.9
Water		1.3
		100.0

Physical Properties.—The flint clay and gray rock slake to fine scales, while the blue rock does not slake for weeks in water. The flint clay requires 28 per cent of water to develop a normal molding consistency, its maximum plasticity is 15, air shrinkage 4 per cent, tensile strength 58 pounds, or when weathered, 96 pounds to the square inch. It vitrifies at cone 26 (3002° F.) with 2 per cent, fire shrinkage, and becomes viscous near cone 28 (3074° F.).

The gray rock requires 24 per cent of water for normal molding consistency, has maximum plasticity of 17, air shrinkage of 4 per cent, and tensile strength of 40 pounds, or if weathered reaches 85 pounds. Incipient fusion begins at cone 1 (2102° F.), with fire shrinkage of 5 per cent, it is vitrified at cone 5 (2246° F.), with shrinkage of 6 per cent, and burns brown.

The blue rock requires 26 per cent of water for normal molding consistency, its maximum plasticity is 15, air shrinkage 4 per cent, tensile strength 46 pounds, or if weathered 110 pounds. It begins to vitrify at cone 1 (2102° F.), with 3 per cent shrinkage, and is complete at cone 5 (2246° F.), with shrinkage of 6 per cent, and burns to a light brown color.

The Clarion clay has been considered in this section of the State as especially adapted to the manufacture of sewer pipe. The clay was sampled in an old entry at the Etna plant. The analysis of this clay and of the overlying 40 feet of buff shales formerly used for common building brick are shown in the following table:

Etna Mine, Clarion Clay and Shales.

	Clay.	Shales
Silica	57.52	57.89
Alumina	21.76	21.59
Ferric iron	3.41	5.62
Ferrous iron	3.70	1.26
Magnesium	0.88	1.55
Lime	0.60	0.61
Sodium	0.03	0.29
Potassium	3.57	3.28
Water	0.86	1.27
Titanium	0.83	0.72
Phosphorus	0.14	0.21
Loss of ignition	7.27	6.18
Total	100.57	100.00

The percentage of fusible elements in the Clarion clay is 11.59, very much higher than in the Lower Kittanning flint clay, and its percentage of silica is higher, which is desirable in sewer pipe clays in order that the salt uniting with the silica may form a good glaze. Its composition agrees very closely with that of the Lower Kittanning gray shale clay. The composition is not very different from that of the overlying shales, though the physical appearance is in marked contrast. While the lower clay has the high percentage of iron, it burns to a light brown color.

Physical Properties.—The clay requires 26 per cent of water for normal molding consistency, its maximum plasticity is 17, air shrinkage 3½ per cent, its tensile strength 40, or if weathered 68 pounds. Incipient fusion is reached at cone 1 (2102° F.), with shrinkage of 2 per cent. and complete vitrification at cone 5 (2246° F.), with 10 per cent of fire shrinkage.

The shale requires 27 per cent of water for normal molding consistency, its maximum plasticity is 15, air shrinkage 4 per cent, tensile strength 36 pounds, or if weathered 70 pounds. Incipient fusion occurs at cone 1 (2102° F.), with 8 per cent fire shrinkage, and the shale gives a red product.

Kenilworth Brick Company.—The plant of this company is located one mile above Congo, on the Pennsylvania railroad. It was built a number of years ago and the Clarion clay was obtained by a shaft 30 feet deep, located on the hill above. The plant was destroyed by fire.

During the summer of 1906 the plant was rebuilt and a mine opened into the Lower Kittanning clay 95 feet above, where the

clay reaches 18 feet in thickness, with two or three feet of coal over it. The equipment includes a Bonnot side cut auger brick machine of 50,000 brick daily capacity, three nine-foot dry pans, 8½-foot pug mill, four double track tunnel driers 110 feet long, with a capacity of 50,000 brick. The brick are burned with gas in 11 down-draft kilns 28 feet in diameter, holding 60,000 brick each, also one 35-foot kiln.

ROAD MATERIALS.

Limestones furnish a supply of good road material in many parts of the Pan Handle area. Nearly all varieties of limestones are used in this work, but those which show good wearing quality combined with cementing properties are the best.

The subject of good roads has not attracted the attention it deserves in this State, while it has become a most important problem in the adjoining States of Maryland and Ohio, where large sums of money are appropriated by the States for the construction and maintenance of good roads.

While there is a great variety of rocks used for road materials, a number of which are to be found in this State, good limestone is one of the valuable sources of supply, and this State has a large supply of such limestone near railroad lines that has not been quarried or used. Limestone in the hills yields little return to the State, but when quarried and made into good roads proves a source of pleasure and great profit to its citizens.

The State of West Virginia could to-day do no greater favor to the farmers, nor make a more profitable investment than to authorize and appropriate a reasonable sum of money for the investigation of road materials in the State, to be followed by appropriations in co-operation with county subscriptions for the building and maintenance of good roads in the different parts of the State.

In Ohio county of the Pan Handle area this subject of good roads has attracted attention for many years, and no county in the State has so large a proportion of its roads ballasted with rock. Of the 212 miles of road in the county, 200 miles, according to the chairman of the County Board of Commissioners, are macadamized. For the past ten years the county has appropriated $35,000 a year to keep these roads in good condition.

This county is fortunate in the quantity and wide distribution of limestones, so that road material can be obtained at low cost convenient to the roads. The repair and construction of the roads are made under the direction of 31 supervisors, who reside in different parts of the county. The stone quarried, broken, and laid on the road costs from 90 cents to $2.00 a yard, with an average cost of about $1.35. It requires about 12 yards of stone to 100 linear feet of road as used in this county.

The following limestones outcrop in the Pan Handle area:

Dunkard Series.

Washington Limestones.
Elm Grove Limestone.

Monongahela Series.

Waynesburg Limestone.
Uniontown Limestone.
Benwood Limestone.
Sewickley Limestone.
Redstone Limestone.

Conemaugh Series.

Pittsburg Limestones.
Clarksburg Limestone.
Elk Lick Limestone.
Ames or Crinoidal Limestone.
Cambridge Limestone.
Brush Creek Limestone.
Mahoning Limestone.

Allegheny Series.

Upper Freeport Limestone.
Lower Freeport Limestone.
Ferriferous Limestone.

The chemical composition, thickness, and general character of these limestones have been given in the chapters on the geology of the Pan Handle area. Some of these rocks are too brittle or

soft to make road material of any value, others are not thick enough to pay for quarrying. The limestones in this area which are valuable for road material will now be described.

Washington Limestones. The Middle and Upper Washington limestones outcrop on many of the creeks in southern and southeastern Ohio county and northern Marshall. The thickness of the strata varies from 5 to 45 feet, and the rock is readily quarried. They are very hard and durable and have been extensively used on the roads of Ohio county.

Elm Grove Limestone. This limestone which comes just above the Waynesburg coal is very shaly and would soon crumble and disintegrate, so is of little or no value for road ballast.

The Waynesburg limestone is a hard rock, but usually of too small thickness to be of value. The Uniontown limestone includes some hard, resistant layers, but most of it is shaly.

Benwood Limestone. This rock outcrops on nearly all the streams near Wheeling, east to Roney's Point, south into Marshall county, and northeast to West Liberty. Its thickness reaches 60 feet, and whenever exposed shows a good body of rock. On fresh exposures it is hard and apparently solid and resistant rock, but on weathering breaks into small angular fragments.

The Benwood limestone is popular for road material in Ohio county on account of its availability, ease of quarrying and crushing, thus saving in labor and cost. However, these latter qualities lower its actual value, for it is soon ground to dust and requires frequent renewal. It is of far less value for road material than other available limestones in the same area, but on account of its cementing property, could be mixed with other limestones of the area to good advantage.

Sewickley Limestone. This stratum is found about 30 to 40 feet above the outcrop of the great Pittsburg coal. Its thickness varies from a few feet to 40. It also varies greatly in character. In some places it is shaly, in others it weathers into the small angular and brittle blocks like the Benwood limestone. It is sometimes a hard compact rock, valuable for use on the roads. In the Wheeling and Elm Grove area it is a very good road limestone, but has not been used very extensively.

Redstone Limestone. The Redstone limestone occurs just above the Pittsburg coal, and is of good thickness and valuable for

road material. It has been so used south of Wheeling and east on the National road as far as Elm Grove, where it passes under cover of overlying rocks.

The Sewickley and Redstone limestones are available in Brooke county to the northern line, but very little work has been done on macadamizing the roads of this county or Hancock.

The Pittsburg limestones, while of good quality, are usually too thin to be of value except in the immediate neighborhood of their outcrop. The Clarksburg and Elk Lick limestones are not well developed in this area.

Ames Limestone. Near the southern outcrop of the Ames limestone in the southern part of Brooke county, the stratum is only 3 to 5 feet thick and weathers into shaly layers, but further north near Wellsburg it has a greater thickness and apparently is of better quality.

On Cross creek, in Brooke county, and further north this limestone is 8 to 12 feet thick, outcropping in solid ledges. It is well exposed through Hancock county. The Ames limestone has not been used for road material at any point, and no use is made of the rock. While not the best road material, it would be equal, if not superior in value to the Benwood limestone, which is used on many roads in Ohio county.

Many places in this area could be selected where the Ames could be economically quarried and its use on some of the poor roads at the north would result in a great improvement. This subject well deserves the careful attention of the road commissioners and the people of Brooke and Hancock counties, for these counties are behind Ohio county in good roads.

There are three roads in Brooke county which deserve special mention. The Wellsburg and Waynesburg pike through Fowlersville is macadamized across the county and kept in good repair. The Wellsburg and Bethany pike, with its rock tunnels, is one of the unique roads of the country, and a popular drive. It is kept in good condition over most of the distance.

The new driveway now under construction from Middle Ferry opposite Steubenville, north to Wheeling Junction and south to Wellsburg, will be one of the finest roads in the Ohio valley. Good progress has been made on improving the roads near Colliers. In Hancock county the subject of good roads has

attracted less attention than in Brooke, and there is room for great improvement.

Cambridge Limestone. This limestone is similar in character to the Ames, but its thickness is usually less. It would be available at a number of places in the northern part of Brooke county and in Hancock, but so far it has not been used.

The Brush Creek, Mahoning, Upper and Lower Freeport limestones, while often of good quality, are usually too thin to be of much value except for local use where they are well exposed so as not to require much labor in quarrying. The Ferriferous limestone, while an important stratum in Pennsylvania and some parts of Ohio, is reduced to a thin shaly layer a few inches thick in Hancock county and is therefore of no value.

Testing of Road Materials.

In former years roads were improved by a system of grading and drainage which depended on the ideas of the various road overseers, and were sometimes good and often bad. The science of good road construction was not well established. Materials were used which were at hand, and poor rock was often taken when better was available.

The subject of good roads was a live one only at the periods of the year when road taxes must be worked out, and often the most important problem was to serve this time as quickly and with as little labor as possible. This method, unfortunately, still survives in some parts of the country, but the people are beginning more and more to consider and realize the importance of the subject of scientific road building. The government has organized a department of public roads, managed by a corps of expert men, and equipped with modern testing machinery, whereby the qualities of these various rocks can be determined. It is possible by these tests to determine whether a given rock is suitable for roads, and which of a series of rocks is best for this purpose.

Several samples of road materials used in Ohio county were collected and sent to Washington where they were tested by the Department of Public Roads for the West Virginia Geological Survey, and the results are appended.

The tests which are now applied to road materials are, spe-

cific gravity, absorption, per cent of wear, cementing value, toughness; and hardness.

The specific gravity test is a clue to the density of the rock and gives its weight per cubic foot. The absorption test determines the porosity of the rock, the more porous rocks would hold more water, which by freezing in the winter, would aid in breaking the rock, causing it to crumble.

Abrasion Test. A method of testing the abrasion or per cent of wear on road materials has been in use in Paris since 1878, and for a number of years in this country. The following description of the method is taken from Maryland Geological report:

The Deval machine used for this purpose consists of an iron cylinder 8 inches in diameter and 13½ inches deep, mounted diagonally on a rotating axis. The stone is broken into pieces that will pass through a 2½-inch ring, and 11 pounds of the stone are placed in the cylinder which is firmly closed and rotated at the rate of 30 turns to the minute for five hours, making altogether 10,000 revolutions.

At each turn the stone rolls over from one end of the cylinder to the other and the edges are gradually broken off and the smooth particles thus formed are ground to dust. Before being placed in the cylinder the stone is carefully cleaned and weighed; after the experiment it is again cleaned and weighed together with all pieces larger than 1-16 of an inch. The difference between these weighings gives the amount of dust formed and is the test of the wearing quality of the stone. These results in France have been found to agree very closely with the results obtained by many years' study of the roads themselves.

The French engineers have adopted a *coefficient of wear* to indicate the quality of the stone. They find that very few rocks in these tests form less dust than 20 grams to each kilogram of rock, or about 2 per cent, and they adopt the number 20 as the coefficient of the best rocks. The coefficient of other rocks is obtained by multiplying this number by 20, divided by the amount of dust formed per kilogram of rock, using the formula,

$$q = \frac{20 \times 20}{u}$$

where q is the coefficient of wear, u the quantity of dust formed

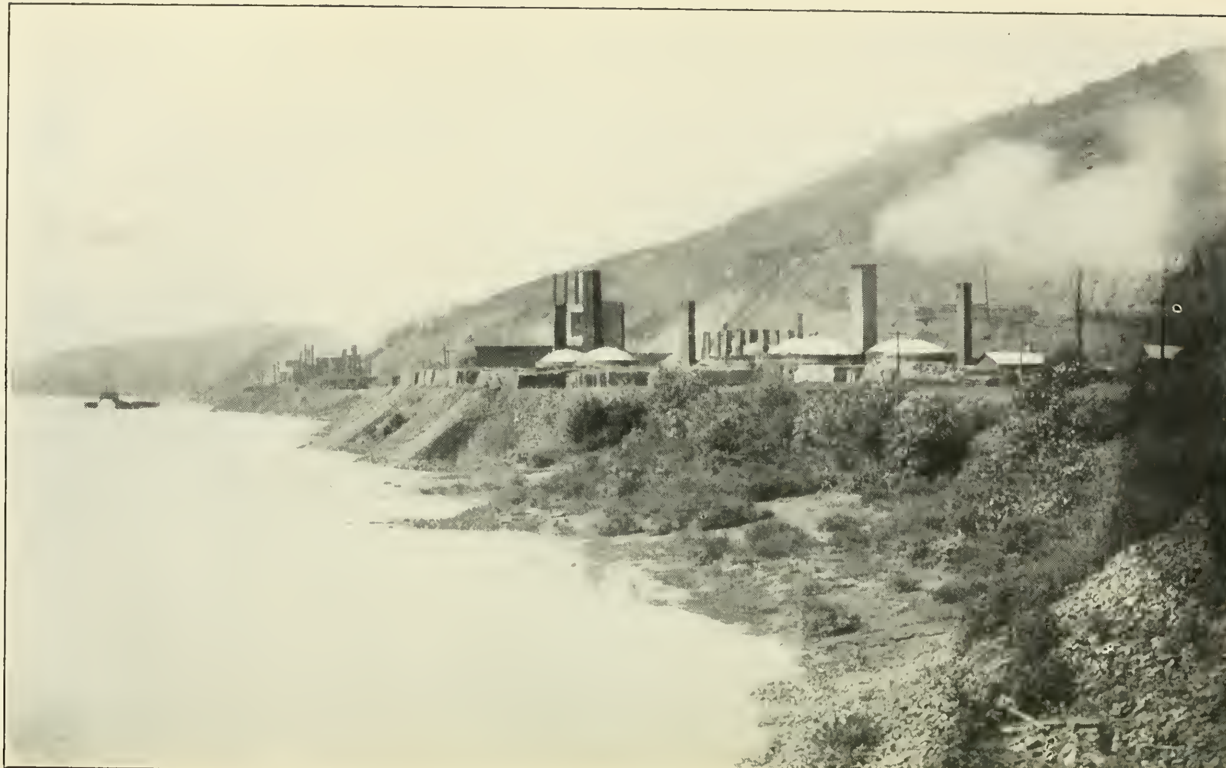

Plate XIV.—Ohio River Bluffs and Brick Plants of Mack Manufacturing Company, New Cumberland, Hancock County.

per kilogram. The French coefficient multiplied by the per cent of wear equals 40.

Cementation Test.[1] The material for this test is run through a small crusher, reducing it to pieces ¼ inch in size and under. One-half kilogram of this material is placed in a ball mill together with sufficient water to produce a stiff dough after grinding. The mill is given 5,000 revolutions at the rate of 30 per minute, after which the dough is taken out and molded in a small steel die, and compressed under a pressure of 1,000 pounds. The briquette is about 1 inch in diameter and height. These briquettes are left in air over night and placed in a hot air bath (100° C.) the next morning and left for four hours. They are then tested under a one kilogram (2.2 pounds) hammer which strikes a number of light blows, and the number of blows necessary to break the briquette is the measure of the cementing value.

According to the work of the Maryland Geological Survey on testing road materials, these tests of per cent of wear and cementation signify:

Wear.	Cementation.	
1 to 7	1 to 4	Bad.
7 to 12	4 to 10	Fair.
12 to 17	10 to 20	Good.
17	20	Excellent.

Toughness Test. The toughness test is made on rock cylinders cut out of the rock, 25 millimeters in diameter and of equal height. These specimens are tested under the impact of a two kilogram (4.4 pounds) falling on a plunger having a spherical end 2 centimeters in diameter. The first blow is delivered from a height of one centimeter, the second from a height of 2 centimeters, etc., until failure takes place. The height of the blow causing failure is given as representing the toughness of the specimen.

Hardness Test. The hardness test is made on rock cores, 25 millimeters in diameter. The cores are held endwise against the surface of a steel disc revolving in a horizontal plane at the rate of about 30 revolutions per minute. The specimens are held in

1. The description of the tests which follow have been furnished by Mr. Vernon M. Pierce of the U. S. Bureau of Public Roads.

suitable clips weighted so as to produce a normal pressure of 1250 grams between the rock core and grinding disc. Crushed quartz sand between 1 and 2 milimeters in size is fed in the path of the specimen to act as the abrasive agent. At the end of 1,000 revolutions of the disc, the sample is taken out and its loss in weight is used in determining the hardness of the specimen by the following formula:

$$h = 20 - \frac{w}{3}$$

where **h** is the hardness, and **w** is the loss in grams per 1,000 revolutions.

For purposes of comparison the following maximum and minimum results of tests on limestone, sandstone, and granite, are given. These tests were made by the United States Bureau of Public Roads up to July 1, 1906.

No. Samples Tested	Kind of Rock	Spec. Grav. Max.	Min.	Avg.	Weight—Pounds per cubic foot Max.	Min.	Avg.	Water absorbed—Pounds per cubic ft Max.	Min.
246	Limestone	3.10	2.10	2.70	193	131	168	13.22	0.03
62	Sandstone	3.10	2.00	2.60	193	125	162	11.60	0.02
84	Granite	3.00	2.50	2.65	187	156	165	1.96	0.04

No. Samples Rock Tested	Kind of Rock	Per cent of wear Max.	Min.	French Coeff of wear Max.	Min	Hardness Max	Min.	Toughness Max.	Min.	Cementing Value Dry Max	Min.	Wet Max.	Min.
246	Limestone ..	34.2	1.8	21.7	1.2	18.7	0.0	21	3	231	1	500	14
62	Sandstone ..	32.8	1.6	25.7	1.2	19.1	0.0	47	3	323	0	500	3
84	Granite	14.8	1.1	37.0	2.7	19.0	13.9	31	4	77	0	88	3

TESTS ON OHIO COUNTY ROAD MATERIALS.

The following five limestones have been used for road material in Ohio county, and samples were sent to Washington, D. C., where they were tested at the Government Bureau of Public Roads.

Limestone from John Hand Farm. The John Hand farm is located two miles and a half a little south of east from Elm Grove on the ridge road to Wherry run. The limestone is at the horizon of the Upper Washington and is 15 to 20 feet thick. It

was formerly used on this ridge road. Its qualities are given by the following tests, with conclusions by the operator:

Specific gravity	2.70	
Weight per cubic foot	168	pounds
Water absorbed per cubic foot	0.96	pounds
Per cent of wear	4.3	
French coefficient of wear	9.2	
Hardness	19.1	
Toughness	7	
Cementing value	15	

A limestone of about average resistance to wear, with a fair cementing value.

Limestone from County Farm. This limestone was sampled on the Ohio county farm, one mile and a quarter east of Elm Grove, just north of the road to Wheeling Heights. The horizon is the Middle Washington limestone, and its thickness is 8 feet. It was formerly quarried and used on the roads in this locality This limestone gave the following results:

Specific gravity	2.65	
Weight per cubic foot	165	pounds
Water absorbed per cubic foot	1.48	"
Per cent of wear	4.8	
French coefficient of wear	8.4	
Hardness	...	
Toughness	7	
Cementing value	21	

A limestone of about average resistance to wear with a fair cementing value.

Limestone from John Korn Farm. The Lower Washington limestone on the Korn farm was quarried for use on the National road and other roads of that area. The location is one mile north-east of Valley Grove near the long farm road to the north. The limestone is 8 to 10 feet thick, and this rock has been quarried at a number of other places east and south of Valley Grove. The following results are given by the tests:

Specific gravity	2.65	
Weight per cubic foot	165	pounds
Water absorbed per cubic foot	1.78	"
Per cent of wear	4.2	
French coefficient of wear	9.5	
Hardness	17.2	
Toughness	11	
Cementing value	24	

A fairly hard and tough limestone with a medium resistance to wear and fair cementing value.

Limestone from the E. Miller Farm. The Miller farm is just over the county line in Marshall county, on Bull run, one mile and a half south of Elm Grove. The horizon is the Benwood limestone which in this locality is 30 to 40 feet thick and is a popular rock on the roads of Ohio county. The lower portion, which is more compact and is often called the "cement rock," was selected for the tests. It is a better grade of limestone than the upper portion, and the tests show that if care is used in the selection of the Benwood limestone the material is valuable for roads.

Specific gravity	2.65	
Weight per cubic foot	165	pounds
Water absorbed per cubic foot	2.86	"
Per cent of wear	4.0	
French coefficient of wear	10.1	
Hardness	17.4	
Toughness	12	
Cementing value	108	

A fairly hard and tough dolomite with a medium resistance to wear and an excellent cementing value. This material is very well adapted for country road and highway traffic.

Limestone from Elm Grove Town. This rock is the Redstone limestone from a quarry in the northern limits of the town of Elm Grove. It also forms the bed of Wheeling creek at this town and is found in the streams and valleys north and east to Wheeling and the Ohio river. There are large quantities of the limestone available and many small quarries have been worked in it for road material. The results of tests on the rock from Elm Grove quarry are as follows:

Specific gravity	2.70	
Weight per cubic foot	163	pounds
Water absorbed per cubic foot	1.3	"
Per cent of wear	3.5	
French coefficient of wear	11.6	
Hardness	18.0	
Toughness	15	
Cementing value	20	

A fairly tough limestone of average hardness and resistance to wear, with a fair cementing value.

These tests are brought together in a single table to which

are added the maximum and minimum tests on 246 samples of limestone at the U. S. Bureau of Public Roads.

	Farm.	Specific Gravity.	Weight per cubic foot.	Water absorbed per cubic foot.	Per cent wear.	French coefficient wear.	Hardness.	Toughness.	Cementing value.
Max. } 246 samples U. S.	....	3.10	193	13.22	34.2	21.7	18.7	21	231
Min. } 246 samples U. S.	....	2.10	131	0.03	1.8	1.2	0.0	3	1
Up. Washington	Hand..	2.70	168	0.96	4.3	9.2	19.1	7	15
Mid. "	County.	2.65	165	1.48	4.8	8.4	.....	7	21
Low. "	Korn ..	2.65	165	1.78	4.2	9.5	17.2	11	24
Benwood	Miller .	2.65	165	2.86	4.0	10.1	17.4	12	103
Redstone	City ...	2.70	168	1.30	3.5	11.6	18.0	15	20

BUILDING STONE.

A number of limestones described under road materials might be used for building stone. The harder rocks would take a very good polish and might be used for ornamental work. Many of these limestones, on account of their brittle character, would have to be quarried by wedge, as blasting would fissure and shatter them. Up to the present time they are not used except occasionally for local use in the foundation of a farm house or barn.

The sandstones of the area vary in weather resistant character, and nearly all weather to a brown or buff color. The durability of some of these sandstones is proved by their use in the old bridges of the National road. These stand today in apparently as good condition as when built a hundred years ago.

In Ohio county there are no large quarries, but when stone is needed for bridge abutments or house foundations a small quarry is opened at a convenient point and stone enough removed to supply the demand. Sometimes the large boulders left by disintegration on the hillsides are broken and used. No stone is shipped by rail from Ohio or Brooke counties.

A small quarry has been opened in the Fish Creek sandstone, one mile south of Elm Grove near the Marshall county line, and a 12 foot stratum is used to supply the local demand. The stone is close grained, of good quality, and it would seem as though larger quarries could be maintained with profit.

The Fish Creek, Waynesburg, Sewickley, and Pittsburg sandstones could be quarried in the hills along the Baltimore & Ohio railroad from Wheeling east to the state line. The Lower Pittsburg sandstone has been quarried in past years, south and east of Wheeling.

In the northern part of Ohio county and southern Brooke, the Pittsburg, Connellsville, and Morgantown sandstones outcrop with good thickness, and apparently of good quality, though the outcrop rock is shaly. When followed into the hill these sandstones will probably prove of good quality.

Just south of Wellsburg in Brooke county, two small quarries have been operated for a number of years in the Saltzburg sandstone. The rock is used for foundations and curbing. There is a very large quantity of this sandstone outcropping on Buffalo creek and north to Wheeling Junction, also in the northeastern part of the county near Colliers.

In Hancock county heavy sandstones are characteristic of the geological series, and include the Mahoning, Freeport and Kittanning sandstones. The number of possible locations for quarries is almost without limit.

Casparis Stone Quarry. At the present time only two quarries are in operation in Hancock county, and one of these, the Casparis quarry, is one of the largest sandstone quarries in the State. This quarry is located one-half mile above the mouth of Kings creek, four miles south of New Cumberland, and is connected by a switch with the Pennsylvania railroad. Plate XII is made from a photograph of the quarry, and shows the face of the rock, which is 80 feet high and is the Lower Freeport sandstone.

This quarry was opened 17 years ago and is owned by the Kings Creek Quarry Company, a branch of the Casparis Stone Co., of Columbus, Ohio. The present quarry is about 200 feet long and the stone is opened with a length of nearly 900 feet and has been worked back about 100 feet into the hill. Four to five

cars of stone are shipped daily through the working season. The face of the quarry runs northeast-southwest, and is broken by north and south nearly vertical joints, 15 to 20 feet apart. Another set of joint planes runs nearly horizontal.

The Lower Freeport coal, 22 inches thick, outcrops at the top of the quarry, and the Middle Kittanning coal, 34 inches, is at the bottom of the quarry, with a heavy fire clay below it. The distance between the two coals is 84 feet. The sandstone on fresh exposure is blue in color but weathers to a brown or buff. It is a hard, rather fine grained rock, and durable under exposure. It is used for bridge foundations, building stone, and curbing.

S. B. Stewart Quarry. Mr. S. B. Stewart has opened a quarry in the sandstone above the Lower Kittanning coal, near the plant of the West Virginia Fire Clay Mfg. Co., one mile below New Cumberland. The quarry is operated under the name of the Toronto Pulp & Grindstone Co.

The stone on fresh fracture is blue in color, weathering brown and is a fairly coarse grained sand with some small flakes of mica scattered through. Twelve feet of the blue ledge is said to be especially adapted to the manufacture of glass grinding stone, and for pulp mills, and equal to the Lancaster, England, stone now imported for these uses. The pulp mill stone is cut out 54 inches in diameter with a 27-inch face, while the glass grinding stone can be obtained in this quarry 72 inches in diameter with a 12-inch face.

The quarry is located above the level of the railroad so that the stone can be loaded by gravity on the cars, and the waste is carried by overhead track to the river bank. The total height of the rock face is about 70 feet, but the upper 10 to 15 feet is shaly. The stone is apparently improving in quality as followed into the hill.

This sandstone above the Lower Kittanning coal has been worked in past years near Globe, north of New Cumberland, and stone from these quarries was used in some of the buildings at the Moundsville penitentiary. Quarries have been worked in the same stone just south of Chester.

MINERAL WATERS.

All springs contain mineral matter in solution and are therefore mineral springs, but some springs contain larger proportions of certain minerals and are designated in popular language as mineral springs, in distinction from other springs whose mineral content is low. Such springs are often of high medicinal value as a curative for various ills. There is probably not a county in the state without medicinal mineral springs. Some of these have long been known and widely advertised, others are only known locally, while still others are unknown and supposed to be without value.

There are in the Pan Handle area a number of mineral springs which are claimed to possess curative principles, and several of these have been examined by reliable chemists, and their results are quoted in this section.

Woodsdale Mineral Springs. At Woodsdale, a suburban town, one mile east of Wheeling, the mineral springs have attracted attention for a number of years. During the past year a company was organized to build a hotel and sanitarium at these springs, which are located a short distance up Woods run north of the National road at Woodsdale.

The chemical composition of the water at the three springs is given by the following analyses quoted from a report by Mr. John W. Adams, and included in a West Virginia University thesis written by G. R. Whitham:

Analyses of Water from Woodsdale Mineral Springs, Ohio County.

(Grains per U. S. Gallon.)

	Spring No. 1.	Apollo, No. 2.	Eureka, No. 3.
Sodium chloride ($NaCl$)	0.763	0.87	0.06
Sodium sulphate ($NaSO_4$)	73.093	13.41	10.48
Potassium sulphate (KSO_4)	2.128	5.42	0.28
Magnesium sulphate ($MgSO_4$)	47.237	62.03	1.57
Magnesium carbonate ($MgCO_3$)	.....	2.18	4.13
Lime sulphate ($CaSO_4$)	44.029	97.96	...
Lime carbonate ($CaCO_3$)	23.035	....	1.06
Alumina (Al_2O_3)	0.174	1.50	0.27
Silica (SiO_2)	0.733		
Iron carbonate ($FeCO_3$)	0.031	0.55	0.62
Lithium carbonate ($LiCO_3$)	trace	trace	1.61
Carbonic acid (CO_2)	10.380	2.77	12.33
Total amount in solution per gallon	201.603	186.69	32.41

Springs Nos. 1 and 3 are classed as table waters, and No. 2 as an aperient or laxative water.

The following analyses of the water from the Smith magnesia springs, near Woodsdale, have been furnished by Prof. B. H. Hite:

Smith's Magnesia Spring. Sampled September 19, 1903, by W. F. Smith, Woodsdale, Wheeling, W. Va.

This water is peddled and has a strong epsom taste.

Analyses of Water from Smith Spring and Well, Woodsdale, Ohio County.

(Grains U. S. Gallon.)

	Smith spring.	Smith well near the spring.
Sodium chloride	0.58	0.59
Lithium chloride	trace	trace
Sodium nitrate	0.21	trace
Sodium sulphate	23.14	2.40
Potassium sulphate	0.43	0.64
Lime sulphate	78.50	45.19
Magnesium sulphate	63.27	25.14
Lime acid carbonate	24.82	25.34
Iron acid carbonate	0.03	trace
Alumina oxide	0.06	
Borax	trace	
Silica	0.74	0.35
Total	191.78	99.65
Free carbon dioxide	1.6 cu. in. per gallon.	

Fairview Mineral Spring. In 1903, in drilling for oil one-half mile northeast of Fairview, Hancock county, and three miles and a half northeast of New Cumberland, a good flow of water with peculiar taste and odor was struck. This mineral water has been extensively used, and even shipped to distant points. Testimonials suggest its value in the treatment of stomach, liver and kidney ailments.

The following analysis was made of this water by F. T. Aschman, a consulting chemist, at Pittsburg:

Analysis of Fairview Mineral Water.
(Grains per U. S. Gallon.)

Sodium chloride	1.020
Sodium bicarbonate	3.711
Sodium sulphate	5.656
Potassium sulphate	0.221
Lithium carbonate	0.139
Lime carbonate	5.947

Lime sulphate	0.157
Magnesium carbonate	1.643
Iron carbonate	0.071
Silica	0.775
Total	19.340
Carbonic acid gas	6.44 grains.

The water has a mild aperient or laxative action.

Mr. C. B. Scott, of Bethany, in Brooke county, owns a mineral well which has attracted attention in that region and is claimed to possess valuable medicinal properties. An analysis of the water from this well has been furnished by Prof. B. H. Hite, chief chemist of the Survey:

Mineral Water from C. B. Scott Well, Bethany.

(Grains U. S. Gallon.)

Ammonium chloride	0.010
Sodium chloride	1.441
Potassium sulphate	1.47
Sodium nitrite	trace.
Sodium nitrate	none.
Sodium borate	small amount.
Sodium carbonate	5.561
Sodium acid carbonate	44.840
Iron acid carbonate	0.056
Manganese acid carbonate	trace.
Potassium acid carbonate	0.301
Magnesium acid carbonate	0.074
Lime tribasic phosphate	0.030
Alumina oxide	0.019
Silica	0.446
Combined water and organic matter	0.283
Total	53.208
Albuminoid nitrogen	.0030 parts.

Iron Alum Spring, Wheeling, W. Va. This spring is located at the roadside on Wheeling hill above the city, on the road leading from the abattoir to the reservoir, not far above the abattoir. The spring was sampled by W. F. Smith, and the analysis has been furnished by Prof. B. H. Hite.

The water is very strongly acid and has an astringent taste. It turns bright yellow on standing, due to oxidation of ferrous iron. Specific gravity at 15 degrees centigrade is 1.0059. The fresh sample is colorless but on standing (quickly on boiling) the water turns yellow and a precipitate of basic ferric sulphate is thrown down.

Iron Alum Spring, Wheeling.
(Grains U. S. Gallon.)

Sodium chloride	9.33
Sodium sulphate	48.91
Potassium sulphate	trace
Lithium chloride	trace
Lime sulphate	78.76
Magnesium sulphate	38.88
Ferrous iron sulphate	92.43
Ferric iron sulphate	16.56
Aluminum sulphate	53.54
Manganese sulphate	trace
Silica	4.59
Free sulphuric acid	23.62
Free nitric acid	trace
Total	366.62

PORTLAND CEMENT.

The cement industry of this country has made wonderful progress in the past ten years, and the increase in production and use from year to year is remarkable. Details with regard to the manufacture of cement, its uses, and the conditions favorable to this industry in West Virginia are given in volume III of the reports of this Survey.

Cement rock is reported from various places in Ohio county, especially near Wheeling. This term as generally used in this section refers to an impure limestone which, on burning, forms a natural cement.

Portland cement in distinction from natural, is an artificial mixture of two rocks, one furnishing the lime, and the other the alumina and silica. Limestone may be used for the first, and clay or shale for the second. However, not all limestones, nor all shales and clays can be used, for they must possess certain necessary characters.

The shales in Ohio county would probably fulfill the requirements for that ingredient, but most of the limestones examined are not suitable. The heavy Uniontown, Benwood, Sewickley, and Redstone, limestones near Wheeling and Elm Grove were tested, but contain 10 to 17 per cent of magnesium carbonate, which is too high for use in Portland cement.

The Washington limestones could probably be used for cement, as their percentage of magnesia is low. They also reach good thickness in the eastern part of the county. They run

rather high in silica and alumina, 20 per cent at a number of the outcrops, and would require a high grade limestone for the mixture. The analysis of the Upper Washington limestone on the Hand farm, given in chapter III, would suggest the possibility of mixing the higher limestone with the lower for the manufacture of Portland cement. These limestones can be found in the ravines from Valley Grove east and south, not far from the Baltimore & Ohio railroad. They can also be found high in the hills farther east.

With the nearness to Wheeling and Pittsburg markets, the river transportation at the former place, this locality deserves attention. The construction and operation of a successful Portland cement mill in Ohio county would be of great value to that area.

On account of the importance of this subject the analyses of the Washington limestones are repeated at this place together with an analysis of the Lehigh valley cement rock:

	Lehigh Valley.	Washington Limestones.		
Lime carbonate	69.26	60.89	72.38	92.42
Magnesium carbonate	3.67	2.28	1.36	0.91
Iron and alumina oxides	6.44	12.00	2.60	1.60
Silica	14.68	18.70	20.90	5.00
Water and organic matter	1.68	5.81	2.65	....

The thickness of these limestones varies from 10 to 45 feet, thus giving a good body of rock, but before its real value can be determined a large number of samples should be tested in order to determine its quality from top to bottom of the formation.

The Ames limestone, further north in Brooke and Ohio counties, is of good quality, but is too thin, reaching a maximum of only 10 to 12 feet, and where it reaches this thickness the cover of overlying rocks is heavy.

PART IV.

The Climate and Soils of the Pan Handle Area.

CHAPTER XI.

THE CLIMATE OF THE PAN HANDLE COUNTIES.

The counties of Hancock, Brooke, Ohio, and the part of Marshall included in the present survey are located in the Ohio valley, within latitude 40° and 40° 37.5′; and longitude 80° 31.1′ and 80° 45.5′ W. The elevation of the land at the south varies from 610 to 1440 feet above mean tide; and at the north, from 680 to 1337 feet.

The value of climatic data depends on the accuracy of the records and the length of time during which observations have been taken. There has been preserved in the city of Wheeling a very complete series of weather records kept by the late Christian Schnepf, a druggist in that city. Mr. Schnepf began to record daily temperatures, the number of fair, cloudy, and rainy days, in July, 1876, for his own pleasure and interest. Near the close of 1891 he was appointed observer for the United States Weather Bureau, and was furnished with standard instruments, including a rain guage, so that the rainfall was recorded from this time.

All of his records before August, 1891, were listed four times a day and no averages made, so that the present use of these records has involved a vast amount of detailed work in averaging the daily, monthly, and annual temperatures in order to secure the data given in this chapter.

There are very few records in the Ohio valley, or near, that have been taken with such care and preserved for this long period of 30 years. The averages here recorded for the first time will prove of much interest and afford a most excellent basis for the

determination of the mean annual temperature of the upper Ohio valley.

After the death of Mr. Schnepf the observations were continued by his clerk, Mr. Charles Grant, under the direction of the Weather Bureau. The Wheeling station is on Market street, with an elevation of 645 feet above tide.

October 1, 1899, an observation station of the U. S. Weather Bureau was established at Highland Springs, four miles and a half east of Wellsburg, where the elevation is 1225 feet, and Mr. C. P. Waugh was appointed observer.

The New Cumberland observations have been seriously interrupted until February, 1901, when Mr. Frank Evans was appointed observer. The station is located at his farm, with an elevation of 987 feet, three miles north of New Cumberland and three-quarters of a mile east of the Ohio river.

The later records from Wheeling and the records from Wellsburg and New Cumberland have kindly been furnished by the local observers, Charles Grant, C. P. Waugh, Frank Evans, and Mr. H. C. Howe, the section director of the U. S. Weather Bureau at Parkersburg.

A general description of the climate of West Virginia and the methods used in taking the weather observations are described in the following paragraphs, taken from the annual report for 1904 of the section director, E. C. Vose:

"The climate varies greatly in different portions of the State. The actual range of latitude is three and one-half degrees, from 37 degrees 10 minutes, to 40 degrees and 40 minutes north, which gives a range of temperature of six degrees, but the range of altitude being so great—4860 feet—gives a range of temperature equal to a range of latitude of from twelve to fifteen degrees. In other words, the vegetable and forest products of the State, as well as the climate, are such as may be found from the southern part of Virginia to the Canadian border.

"The average elevation of the western half of the State is from 1000 to 1200 feet; of the western plateau, from 1500 to 1700 feet; of the eastern plateau, from 2000 to 2200 feet, and of the eastern Pan Handle, from 500 to 700 feet; the average elevation of the State is about 1500 feet.

"The counties bordering along the Ohio river north of Roane

county have about the same character of climate as those in the eastern Pan Handle, although such low temperatures are not reached in the Pan Handle section, the mountains, no doubt, preventing this. The mean annual temperature over these sections is about 53 degrees. These two sections, together with the extreme southeastern portion, get the least mean annual precipitation, averaging from 35 to 40 inches. Over the southwestern portion of the State the mean average temperature will average about 56 degrees, and the mean annual precipitation about 50 inches. The western plateau counties, which extend in a northeasterly and southwesterly direction about 100 miles east of the Ohio river, as well as the eastern plateau counties, have a climate that differs somewhat from the low lands. Over these plateau regions the mean annual temperature is about 52 degrees, and the mean annual rainfall (precipitation) from 45 to 50 inches. The seasons are just a little shorter, and the frosts and snows a little more frequent. The mountain tier of counties has a climate altogether different from those already described. Their spring and fall seasons are quite a little shorter, the snows are deeper and more frequent, and the wind currents are drier and stronger. The mean annual temperature over this section is from 48 to 50 degrees, and the mean annual precipitation over 50 inches. The dates of first killing frosts in autumn and last killing frosts in spring will run from 10 to 15 days earlier and later than in the low lands.

"The mean annual range of temperature over the State is from 6 to 8 degrees, the temperature being highest in the southwest portion and lowest over the mountains. The mean annual range of precipitation is from 15 to 20 inches, the precipitation being greatest over the mountains (due to the greater amount of snow that falls there) and the least over the eastern Pan Handle and extreme southern portion. The winter mean temperature of the western border and the eastern Pan Handle counties is from 31 to 34 degrees; the spring mean, 51 to 53 degrees; the summer mean is 74 degrees, and the fall mean is 55 degrees. The winter and spring precipitation averages about 10 inches; the summer from 10 to 13 inches, and the fall from 7 to 8 inches. The extreme range of temperature is 1.42 degrees, the highest ever recorded being 107 degrees, and the lowest 35 degrees below zero.

The average amount of sunshine for the State is about 50 per cent, and the prevailing direction of the wind is from south to west.

"The mountains afford a delightful retreat for summer, and many people go there. At Terra Alta no record of temperature above 90 degrees has been made; at Elkins and Marlinton, temperatures above 90 degrees are only recorded on an average of five days each year. The summer mean temperature at Terra Alta is only 67 degrees.

"The features of the weather that contribute to a successful crop growing season are numerous, but among them may be mentioned the following: sufficient rain in October and November to germinate wheat and rye, and to get them well stooled and rooted, and then ample snow protection during the winter; just enough rain in April to soften the soil so that plowing can be done; a May that is warm and pleasant, but with enough moisture to germinate the crops, and a summer season that has ample warmth and moisture.

"On the other hand, the features of a season that are unfavorable and that tend to the failure of the staple crops are drouth accompanied by very hot weather in the fall, so that wheat, rye and fall-sown oats will not germinate; then sudden changes in the temperature during the winter, accompanied by frequent periods of hard freezing and thawing weather with but little snow on the ground, which condition tends to winter kill these grains; excessive rains in April and during the summer months, thus preventing the completion of plowing and sowing, badly washing growing crops and seriously damaging hay and grain during harvest; drouths in May and September especially, and also during the summer, these being accompanied by periods of extreme heat, thus drying up and withering the growing crops; abnormally low temperatures during June, July and August, which prevent rapid growth, and killing frost earlier and later than the average dates in May and September.

"The sub-stations in this State for which data are compiled are all equipped with standard Weather Bureau instruments, con-

sisting of self-registering maximum and minimum thermometers, rain guage, and instrument shelter. A brief description of these instruments may not be uninteresting:

"The maximum thermometer is always filled with mercury, sometimes called quicksilver. Its difference from an ordinary thermometer is that there is a constriction in the glass tube, just above the bulb, which prevents the mercury from going into the bulb when the temperature falls. When the temperature rises, however, the expansion forces the mercury through this stricture, and so it always shows the highest point reached for any time, or until it is set. This thermometer is set by whirling it vigorously.

"The minimum thermometer, as used by the Weather Bureau, is always filled with alcohol, and it is therefore easily distinguished from mercurial thermometers. Alcohol is used instead of mercury, because mercury congeals at about 40 degrees below zero, and in some places in the Dakotas and Montana a lower temperature than that even is reached. Besides the alcohol, there is also in the glass tube a little black object called the index, and this is the prime characteristic by which the thermometer is distinguished from all others. When the temperature of the air falls, the weight of the little steel index is so slight that the liquid contracting in the tube does not separate and leave the index up, but drags it back. When the temperature again rises, the expanding fluid passes freely by the index, and its upper end remains at the point of lowest temperature. The thermometer is set by raising the bulb end slightly so that the index may move gently to the top of the column. This thermometer can also be used as an ordinary thermometer as well as a minimum, as the current temperature is always recorded by the head of the alcoholic column.

"The rain guage consists of a galvanized can about three feet high and eight inches in diameter, on the top of which a receiver is placed to catch the rain and to carry it to the measuring tube. If the rainfall should be very heavy, and the tube be

filled, the water will run over into the can, and then it can be measured by emptying into the tube, after that already in the tube has been measured. The diameter of the measuring tube is much smaller than the receiving tube, and rain in consequence fills the measuring tube to a much greater extent than the actual rainfall. In fact it is magnified just ten times. This is so as to make it easier to measure, as light rainfalls occur more frequently than heavy. The reading is always recorded in tenths just the same as it registers on the measuring stick.

"The purpose of taking temperature readings is to record the real temperature of free air, not, however, open to the sky and in the direct rays of the sun. In order to get the proper exposure it is necessary to use a thermometer shelter. This is nothing more than a box with louvered sides made in such a way that the air can move through it with the greatest possible freedom. This is an essential condition in the thermometer exposure. The object of the box or shelter is simply to screen off the direct and reflected sunshine, and the radiation to and from the sky, and to keep the thermometers dry. The shelter is generally raised about four feet above the ground."

TEMPERATURE.

In Table I, the mean monthly and annual temperatures at Wheeling for 30 years are brought together. The lowest mean annual temperature was 52.4° in 1897, while the highest was 60.7° in 1887. The mean annual temperature at Wheeling, based on the records for 30 years, is 57.1°.

The coldest month in the year, according to these records, is January, with an average of 33.9°, and the warmest month is July with an average of 80°. The coldest month in the 30 years was January, 1893, with an average monthly temperature of 23.8°, and the warmest month was July, 1887, with a temperature of 88°.

Table 1.—Mean Monthly and Annual Temperatures Ohio County.

Wheeling	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann'l
1876	....	....	....	....	....	....	80	80.8	68	54	46.8	27	....
1877	31	41.7	40	57.8	63.6	80	81.5	79	70.7	61.9	46.2	46.1	57.5
1878	33.4	39.2	51	63.2	66.8	72.1	85.4	81.3	73.9	58.8	47.8	32	58.7
1879	30.6	34	47.5	56.3	71.5	77.7	84.9	78.7	69.3	67	49.1	43.5	58.3
1880	48.7	42.9	45.7	61.8	77.6	80.7	82.7	81	71.4	57.9	39.3	30.1	60
1881	29.5	34.4	42.5	53.8	73.7	76.6	83.1	81.7	81.4	65.7	48.5	43.6	59.5
1882	35.5	44.6	47.8	59.3	65.7	77.9	81.7	77.9	74.4	68.3	45.3	34.7	59.4
1883	31.3	38.4	40.2	56.9	67.5	78.3	83.1	79.5	70.5	60.7	49.8	40	58
1884	26.7	42.6	45	56.1	69	74.1	80.6	80.6	78.1	64.7	47.2	37.5	58.5
1885	31.3	28.1	35.6	55.9	68.3	76.2	84.1	77.9	70.7	57	46	37.4	55.7
1886	29.4	33	44.3	60.8	69.6	74.9	79.5	79	72.8	61.5	46.8	34.2	57.1
1887	36.2	45	45.4	60.4	77.6	79.3	88	79.6	71.7	58.5	47.2	39.4	60.7
1888	32.6	39.8	42.8	57.8	69	77.4	80.1	78.9	68.5	56	50.1	40	57.7
1889	41.1	34.6	49.8	58.9	71.5	76.3	82.4	78	71.1	55.8	48	49.6	59.7
1890	46.8	47.6	41.4	59.3	68.2	81.0	80.6	74.3	68.8	60.8	49.5	36.3	59.5
1891	37.3	41.1	40.9	64.3	66.1	79.5	78.0	77.0	72.3	56.8	45.1	42.7	58.4
1892	29.9	38.9	38.4	54	64	80.3	78.1	76.6	70.1	58	45.3	35.5	55.7
1893	23.8	35.2	43.9	55.4	58.7	74.8	77.8	74.5	67.5	57.2	44	38.9	54.3
1894	39.4	34.7	49.8	53.6	63.5	72.8	76.2	72.9	70.5	56.7	42.1	37.5	55.8
1895	30.1	24.7	39.4	54.9	63.8	78.6	72	74.8	71.4	50.2	44.5	38.3	53.3
1896	34.2	34.5	36.3	60.4	71	70.4	75.1	74.6	66.5	51.5	49.5	37.3	55.1
1897	29.4	37.6	47	53.2	60.4	71.4	79.5	72.2	66.5	58.1	45.4	38.4	52.4
1898	37.1	33.6	49.8	51.9	65.9	72.9	80.6	78.2	70.7	58.1	43.6	33.2	56.3
1899	32.5	27	43	57.8	67.9	75.5	78.5	77.6	67.5	58.6	44.2	41.2	55.9
1900	35.9	30.7	39.3	56.5	68	76.8	81.2	82	75.6	64.7	47.4	34	57.6
1901	34.3	28.1	45.9	51.4	66	76.4	84.3	76.1	69	58.6	41.9	34.9	55.5
1902	32.1	28.9	46.5	55.3	67.3	73	81	74.3	68.5	59	52.1	35.3	56.1
1903	32.9	36.5	52.4	54.4	72.8	69.2	78.2	74.9	65.8	58.3	40.9	30.7	55.6
1904	28.2	28.2	46.7	49.7	67.3	78.6	74.8	77.8	71.9	57.8	44.2	29.3	54.5
1905	28.8	28.4	49.8	55.2	70.2	75.0	77.0	79.4	73.0	56.0	45.3	39.4	56.4
1906	48.8	31.4	46.1	62.2	68.0	78.3	80.8	82.6	78.9	60.1	49.0	41.0	60.6
Av. Mean Temp.	33.9	35.5	44.5	56.9	68.0	76.2	80.0	77.8	71.2	59.0	46.2	37.3	57.1

Figure 28 illustrates in graphic form the variations in mean annual temperatures at Wheeling for 29 years.

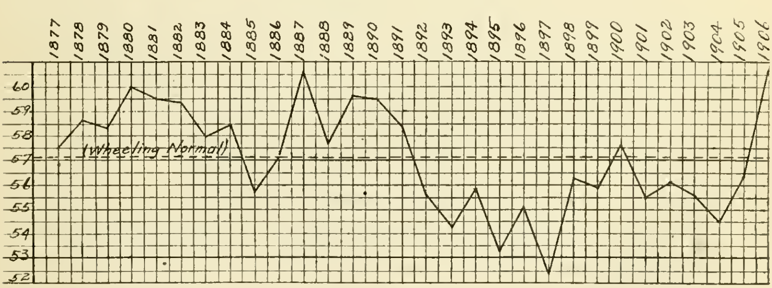

Fig. 28.—Diagram showing the mean annual temperatures at Wheeling, 1877—1906.

Diagram for figures 28 to 37 and also No. 1 were made by Ray V. Hennen, Engineer and Chief Clerk of the Survey.

Tables II and III give the mean monthly and annual temperatures at Wellsburg and New Cumberland for seven and six years respectively. The lowest mean annual temperature at Wellsburg in this period was 46.8° in 1900, and the highest was 51.7° in 1906. The mean temperature for the seven years was 49.5° or 7.6° lower than Wheeling, but the elevation of the Wellsburg station is 580 feet higher, and the annual temperatures appear to be more uniform. The coldest month of the year, according to these records, is February, with an average temperature of 25.2°, and the warmest month was August, with a temperature of 70.1°, thus giving lower temperatures than the Wheeling station. The coldest month in the seven years was February, 1905, with a temperature of 21°, and the warmest month was July, 1901, with a temperature of 75.7°.

Table II.—Mean Monthly and Annual Temperatures Wellsburg.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug	Sept.	Oct.	Nov.	Dec.	Ann'l.
1900	31.3	30.2	32.3	49.8	62.2	68.5	71.9	74.5	66.6	60.0	43.7	31.4	46.8
1901	29.7	21.5	39.7	45.7	59.5	69.6	75.7	72.0	63.0	53.0	35.8	29.6	49.5
1902	27.2	23.2	41.6	47.4	62.1	65.4	72.2	67.2	62.7	52.2	48.4	30.0	51.1
1903	28.0	30.0	47.4	49.6	63.9	63.4	71.4	70.0	64.2	53.3	36.2	23.8	50.1
1904	21.7	23.0	39.4	42.2	60.8	68.2	69.8	67.2	64.2	51.8	39.9	28.0	48.2
1905	24.4	21.0	41.3	47.1	59.6	67.0	71.1	66.8	63.0	51.1	41.8	33.0	49.3
1906	35.8	27.8	32.2	51.3	60.8	68.9	70.8	73.0	67.7	52.0	41.6	32.2	51.2
Average	28.3	25.2	39.1	47.6	61.3	67.4	71.8	70.1	64.5	53.3	41.0	29.6	49.5

The elevation of the New Cumberland station (987 feet) is 342 feet higher than Wheeling, and 238 feet lower than the Wellsburg station. According to table III, the mean annual temperature at New Cumberland is 50.7°, or 1.2° higher than at Wellsburg, 6.4° lower than Wheeling. These differences are thus seen to depend in a large degree on altitude.

The lowest mean annual temperature was 48.7° in 1904, and the highest was in 1901, 52.6°, though in this year no observations were made in the cold month of January, so that the highest annual temperature was in 1901 or 1902. The coldest month of the year at this station is February with average temperature of 25.°9, and the warmest month is July, with temperature of 72°.

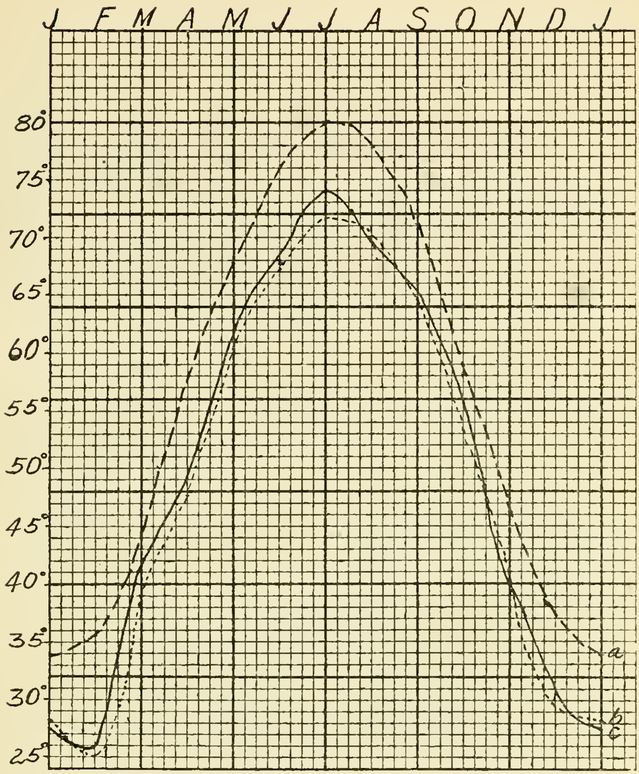

Fig. 29.—Mean monthly temperatures.

a.—Wheeling.
b.—Wellsburg.
c.—New Cumberland.

Figure 29 shows a diagram of the mean monthly temperatures at Wheeling, Wellsburg and New Cumberland.

The records at Wellsburg and New Cumberland extend over too limited a period of time to give accurate average temperatures, or to justify comparison with the Wheeling records, but they are of interest in showing the differences in climate at the three localities. The changes in mean annual temperatures from year to year, and the relation of these changes to the normal, are illustrated by the curves in figure 30.

Table III.—Mean Monthly and Annual Temperatures New Cumberland.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann'l.
1899	....	....	....	....	....	....	....	....	....	....	....	....	....
1900.	....	....	....	....	....	....	....	....	....	....	....	....	....
1901	....	22.1	40.5	45.0	61.5	70.8	77	71.8	67.5	55.5	37.0	30.3	52.6
1902	27.6	29.0	47.2	48.5	63.5	66.5	72	65.5	62.5	54.5	49.0	30.5	51.3
1903	27.5	31.0	49.0	50.5	63.0	63.0	70.5	70.0	64.5	60.5	34.5	29.5	51.1
1904	22.8	25.0	39.9	44.7	60.9	68.8	69.6	66.8	64.0	52.2	40.9	28.3	48.7
1905	23.6	22.4	42.3	48.4	61.2	67.8	71.8	70.0	63.8	52.6	39.8	33.2	49.7
1906	36.4	26.2	32.3	50.4	60.1	69.2	71.1	74.0	67.9	52.1	42.7	31.8	51.2
Average	27.6	25.9	41.9	47.9	61.7	67.7	72	69.7	65	54.6	40.6	30.6	50.7

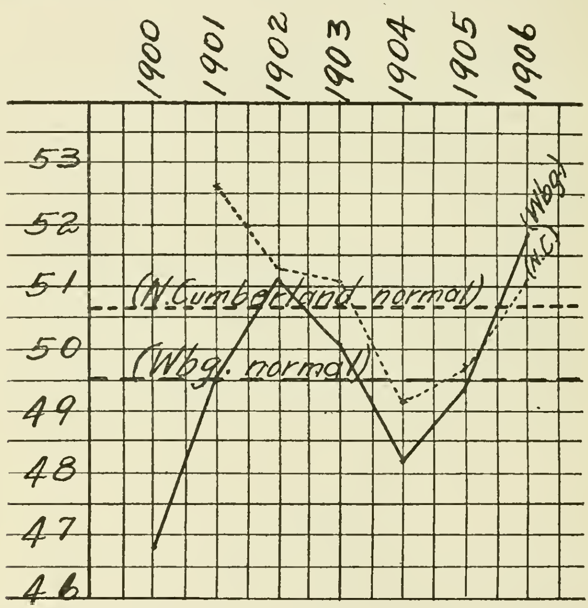

Fig. 30.—Diagram showing the mean annual temperatures at Wellsburg and New Cumberland, 1900—1906.

Table IV shows the maximum and minimum recorded temperatures at Wheeling during the twelve months of the 30-year period. The highest recorded temperature was July 17, 1887, at 3 p. m., when the thermometer registered 104°. This month was also the warmest month in the 30 years. The temperature reached 103° in July, 1881, 1898, 1901; and 102° in July, 1903, 1904,

1905. A temperature of 100° is recorded in the months of June, July, August and September.

The lowest recorded temperature was 16 degrees below zero on February 9, 1899. The next lowest temperature was recorded in December, 1880, and January, 1904, when the thermometer reached 8 degrees below zero. Below zero temperatures are recorded in the months of January, February, and December. In January, below zero temperatures were recorded in only ten years of the thirty; in February, six years in thirty; in December, four years in thirty.

Table IV.—Maximum and Minimum Recorded Temperatures Ohio County.

WHEELING	January		February		March		April		May		June	
	Max	Min.	Max	Min	Max	Min.	Max	Min.	Max	Min.	Max	Min.
1876	....	....	....	....	....	....	....	....	....	....	....	....
1877	54	2	62	21	66	13	80	40	93	42	89	57
1878	52	– 4	61	10	74	24	86	41	83	48	93	57
1879	53	-10	58	10	75	24	84	28	94	44	94	50
1880	68	22	70	6	70	21	85	36	95	41	99	56
1881	49	– 4	64	– 6	64	27	86	28	94	50	94	58
1882	62	8	65	28	75	30	84	30	85	48	99	58
1883	58	6	74	18	70	18	86	32	89	45	94	58
1884	53	– 7	68	4	71	10	79	32	87	46	98	62
1885	67	1	54	– 6	62	8	85	32	87	44	92	52
1886	59	– 4	62	– 4	75	13	87	31	88	47	93	50
1887	71	7	70	18	74	18	89	27	95	53	95	60
1888	64	4	62	7	74	15	87	32	84	41	98	50
1889	61	22	57	4	75	28	87	26	92	39	91	50
1890	69	12	71	20	71	6	80	32	87	38	95	59
1891	60	19	69	11	68	5	87	30	87	38	95	59
1892	63	2	61	10	68	16	82	31	88	40	97	57
1893	55	– 3	60	6	81	19	86	34	85	41	96	56
1894	63	12	67	12	84	19	86	27	90	48	96	44
1895	58	– 1	62	0	66	20	81	29	96	35	98	47
1896	55	6	62	1	72	9	92	26	92	52	91	48
1897	65	– 4	58	12	73	28	84	26	83	38	93	45
1898	69	9	67	2	83	21	84	22	87	40	94	50
1899	64	– 1	63	–16	73	12	92	28	90	45	97	50
1900	57	5	78	0	62	6	83	26	92	34	95	58
1901	61	15	46	8	77	4	85	30	92	44	98	50
1902	53	12	66	2	76	14	89	32	93	41	98	52
1903	66	4	64	– 1	80	65	83	23	92	47	82	55
1904	58	– 8	62	0	83	23	77	27	90	42	96	59
1905	58	0	49	– 4	83	22	84	33	91	39	102	50
1906	80	12	69	0	70	15	85	33	96	43	98	60
Highest and lowest recorded tem..	80 1906	– 8 1904	78 1900	–16 1899	84 1894	4 1901	92 1896 1899	22 1898	96 1895	34 1900	102 1905	44 1894 ....

Table IV.—Maximum and Minimum Recorded Temperatures Ohio County.—Continued.

WHEELING	July Max	July Min.	Aug. Max	Aug. Min	Sept. Max	Sept. Min.	Oct. Max	Oct. Min	Nov. Max	Nov. Min.	Dec Max.	Dec Min.
1876	97	66	94	58	85	50	76	34	76	29	50	– 2
1877	94	68	92	66	86	52	81	46	64	17	60	27
1878	100	66	94	62	90	50	83	36	64	28	54	5
1879	100	66	93	59	91	44	90	31	76	20	64	8
1880	99	64	97	61	94	52	80	33	72	6	66	– 8
1881	103	67	98	66	100	55	90	40	76	20	68	21
1882	94	64	94	65	93	56	81	44	70	25	57	0
1883	99	63	93	60	94	48	83	40	71	17	64	18
1884	96	59	97	59	98	48	93	31	67	25	65	– 3
1885	99	57	94	52	85	46	82	37	72	24	69	9
1886	94	60	93	56	93	49	80	40	72	28	54	9
1887	104	68	98	52	94	43	82	25	77	16	62	11
1888	94	56	96	55	86	46	76	37	77	27	63	16
1889	96	60	92	55	94	46	77	27	72	24	69	19
1890	97	58	97	52	92	45	80	38	75	28	53	16
1891	93	54	97	52	91	51	88	33	70	17	64	19
1892	100	59	96½	60	90	49	80	37	75	24	71	2
1893	99	60	95	58	92	41	85	30	70	17	65	16
1894	97	50	95	52	93	42	81	33	68	19	62	– 4
1895	94	52	94	49	95	44	74	25	71	26	66	10
1896	94	52	96	51	90	40	78	32	75	25	60	12
1897	101	61	96	50	95	36	85	32	69	18	64	9
1898	103	48	94	54	96	44	91	30	70	13	66	4
1899	97	58	97	58	96	40	82	32	68	30	64	5
1900	98	52	100	60	97	49	89	35	76	18	60	14
1901	103	54	98	60	89	47	82	35	69	24	69	1
1902	101	62	93	51	86	45	76	32	76	31	62	11
1903	102	57	102	56	98	43	89	33	69	20	53	8
1904	102	60	95	52	92	40	87	32	73	26	65	0
1905	102	58	98	55	98	44	81	30	69	20	62	18
1906	101	56	....	....	....	....	84	30	84	28	70	16
Highest and	104	50	102	49	100	36	93	25	77	6	71	– 8
lowest re-	1887	1894	1903	1895	1881	1897	1884	1887	1887	1880	1892	1880
corded tem..	....	....	....	....	....	....	....	1895	1888	....	....	....

In table V the maximum and minimum daily average temperatures at Wheeling are recorded by months for 15½ years. The coldest day in this period was January 3, 1897, when the average daily temperature was 2° below zero, and the warmest day was July 17, 1887, with an average temperature of 97°. The average daily range of temperature during these years was:

Jan.	Feb.	March.	April.	May.	June.
41.0	40.4	33.5	37.7	29	13.4
July.	Aug.	Sept.	Oct.	Nov.	Dec.
17.4	19.2	25.5	30.3	37.8	38.2

The variation in daily temperature is least in the summer months, and greatest in months of December, January, and February.

Table V.—Maximum and Minimum Daily Average Temperatures for 16 Years.

WHEELI G	January Max.	January Min.	February Max.	February Min.	March Max.	March Min.	April Max.	April Min.	May Max.	May Min.	June Max.	June Min.
1876	....	....	....	....	....	....	....	....	....	....	....	....
1877	47½	12	55	30½	57½	23	68	42½	85	41	84	63
1878	47½	9	54	23	65	30	79	48	78	52	89	58
1879	51	−2	51	18	70	33	77	30	88	57	87	64
1880	62	31	65	23	65	35	76	38	88	56	93	64
1881	46	14	58	7	57	27	75	31	86	57	84	62
1882	57	18	61	30	60	36	79	32	77	52	89	63
1883	51	9	67	22	63	23	79	35	81	47	88	68
1884	48	1½	63	12	64	21	70	44	82	59	89	66
1885	59	10	49	5	52	14	74	34	80	49	88	65
1886	55	2	54	8	66	22	78	36	79	56	85	64
1887	64	12	68	23	67	26	78	35	88	65	89	65
1888	60	12	54	18	68	21	77	45	78	54	91	64
1889	55½	29	50	10	64	37	77	44	85	51	86	54
1890	68	20	65½	28	66½	22	72	44	80	51½	90½	71
1891	57	27	65	17	57	19½	79	35	76	48½	92½	72½
High and low	68	—2	68	5	70	14	79	30	88	41	93	54
Average	55.2	14.2	58.6	18.2	59.4	25.9	75.9	38.2	82	53	88.2	74.8

WHEELING	July Max.	July Min.	August Max.	August Min.	September Max	September Min.	October Max.	October Min.	November Max.	November Min.	December Max	December Min.
1876	92	71	90	71	80	55	68	37	68	31	45	2
1877	88½	73	86½	70½	81	62	74	51	60	19	62	24
1878	93	78	89	74	85	59	75	41	58	41	52	11
1879	92	78	89	65	84	56	81	44	72	28	60	16
1880	91	75	88	67	88	56	72	39	62	16	58	0
1881	95	70	89	76	91	69	83	53	68	26	59	27
1882	88	69	86	71	87	62	75	53	68	32	49	9
1883	92	71	87	66	86	58	75	51	67	26	56	24
1884	88	74	89	72	89	66	86	43	59	26	59	7
1885	91	71	85	64	79	55	73	40	66	34	55	15
1886	85	73	85	71	83	60	69	49	66	31	49	15
1887	97	81	92	66	86	54	75	35	68	24	58	16
1888	87	67	89	69	78	50	70	44	74	36	54	26
1889	90	75½	87	71	85	54	69	45	67	27½	63	31
1890	91	73	91½	65	85	60	74	43	73	35	48	29
1891	85	68	89	66	79½	63	77	44	66	25	62	26
High and low	97	67	92	64	91	50	86	35	74	16	63	0
Average.....	90.3	72.9	88.2	69	84.1	58.6	74.8	44.5	66.3	28.5	55.5	17.3

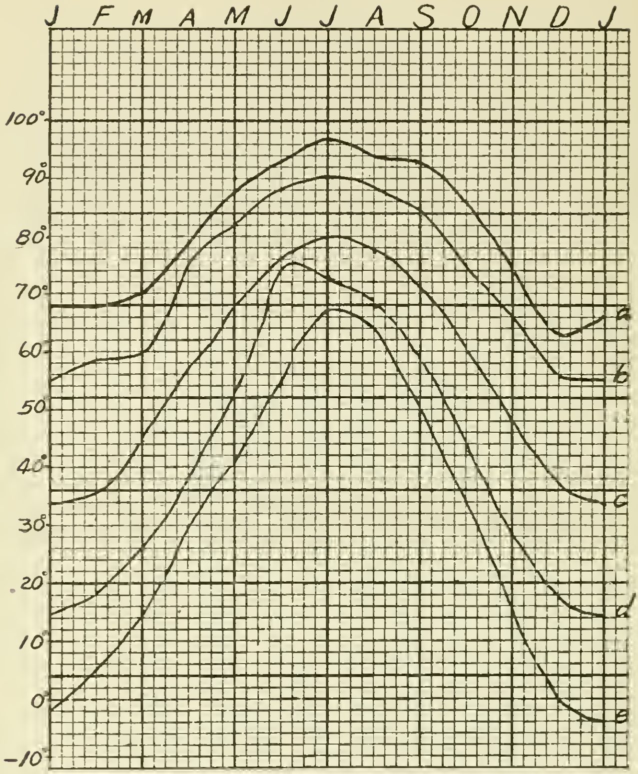

Fig. 31.—Daily temperatures at Wheeling (16 years).
a.—Absolute maximum.
b.—Average maximum.
c.—Normal temperature (30 years).
d.—Average minimum.
e.—Absolute minimum.

Figure 31 illustrates by curves the absolute maximum, minimum, and average temperatures at Wheeling for 15½ years.

Tables VI and VII give the maximum and minimum recorded temperatures at Wellsburg for seven years, and New Cumberland for six years. The maximum temperature recorded at Wellsburg was 94°, July 1, 1901, and the temperature was 90° or over in only six months of the 84. The minimum temperature recorded at this station was 9 degrees below zero on February 3, 1905. In January below zero temperatures were recorded in four years of the seven; in February, six years with a zero

temperature in the seventh; in December, one year of the seven, and the thermometer registered below zero in March, 1901.

Table VI.—Maximum and minimum Recorded Temperatures at Wellsburg.

	January Max.	January Min.	February Max.	February Min.	March Max	March Min.	April Max.	April Min.	May Max	May Min	June Max	June Min.
1900	56	– 2	73	– 5	56	0	76	21	87	28	88	50
1901	53	5	44	0	72	– 1	79	25	82	39	90	41
1902	47	5	59	– 2	69	8	82	25	88	30	88	42
1903	61	– 1	60	– 6	75	22	78	20	85	32	81	45
1904	61	– 8	58	– 8	74	13	75	13	87	36	86	49
1905	54	– 3	45	– 9	79	12	77	26	85	35	88	43
1906	71	7	64	– 7	59	6	79	23	84	32	87	45
Max.and min.	71	– 8	73	– 9	79	– 1	82	13	88	28	90	41

	July Max.	July Min	August Max.	August Min.	September Max.	September Min.	October Max.	October Min.	November Max.	November Min.	December Max.	December Min.
1900	90	52	91	50	90	45	86	34	70	21	56	6
1901	94	53	89	52	83	37	76	29	67	18	66	– 5
1902	89	52	85	45	81	37	74	30	69	25	56	5
1903	91	49	89	48	85	36	83	28	68	11	45	1
1904	88	50	86	46	86	32	79	26	64	19	64	1
1905	89	53	86	48	83	39	77	32	60	16	58	13
1906	85	52	86	53	85	46	75	24	72	22	60	1
Max.and min.	94	49	91	46	90	32	86	24	72	11	66	– 5

The maximum temperature recorded at New Cumberland was 96° July 21, 1901, and a temperature of 90° or over was recorded in 12 months of the 72. The lowest temperature was 18 degrees below zero on January 5, 1904, and the next lowest 11 degrees below on February 3, 1905. Below zero temperatures were recorded in January in three years of the five; in February, five years of the six; and in December, two years in six.

Table VII.—Maximum and Minimum Recorded Temperatures New Cumberland.

	January Max.	January Min	February Max	February Min.	March Max	March Min.	April Max	April Min.	May Max.	May Min	June Max.	June Min.
1901	....	....	42	2	71	2	83	24	88	34	91	52
1902	47	5	62	– 3	70	6	87	26	90	30	88	42
1903	60	– 1	55	– 7	78	22	80	18	86	28	82	45
1904	65	–18	60	– 7	76	14	73	17	89	38	88	45
1905	58	– 8	47	–11	83	10	78	26	86	33	88	40
1906	73	8	65	– 8	60	4	80	23	85	32	91	42
Max. and Min.	73	–18	65	–11	83	2	87	17	90	28	91	40

	July		August		September		October		November		December	
	Max.	Min	Max.	Min.	Max.	Min.	Max.	Min	Max	Min	Max.	Min.
1901	96	57	92	70	86	40	75	28	69	20	67	− 3
1902	92	52	87	45	85	33	75	28	72	23	58	1
1903	94	48	91	44	88	35	85	25	70	12	50	4
1904	90	50	88	41	88	30	85	21	68	18	64	− 5
1905	91	53	88	44	84	35	79	25	60	16	50	12
1906	89	48	93	47	93	42	80	22	74	20	60	0
Max. and Min.	96	48	93	41	93	30	85	21	74	12	67	− 5

Table VIII.—Maximum and Minimum Daily Average Temperatures at Wellsburg.

	January		February		March		April		May		June	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1900	39.0	23.0	35.9	17.5	41.0	23.5	59.5	39.0	73.9	50.4	79.1	59.1
1901	33.9	22.7	27.3	14.0	49.2	30.2	55.0	36.5	69.4	49.6	79.9	59.6
1902	34.7	19.7	30.4	15.9	50.0	32.2	56.5	38.2	74.0	50.2	75.5	55.4
1903	39.7	21.0	37.9	22.1	56.5	38.2	59.6	39.7	75.5	52.3	72.4	54.5
1904	30.2	13.2	33.2	12.9	49.2	29.5	53.3	35.0	71.4	50.2	77.4	58.9
1905	30.3	14.5	29.1	14.6	51.5	32.6	57.9	38.2	70.0	50.8	74.6	56.9
1906	43.5	28.0	38.0	17.6	39.3	25.2	61.9	40.7	71.3	50.3	77.3	60.5
Max. and Min.	43.5	13.2	38.0	12.9	56.5	25.2	61.9	35	75.5	49.6	79.9	54.5

	July		August		September		October		November		December	
	Max.	Min.	Max.	Min.	Max	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1900	81.1	62.8	81.9	68.2	79.0	58.7	70.2	49.3	51.7	36.	35.	24.6
1901	85.1	66.4	81.1	62.9	71.9	54.0	64.2	41.9	42.7	29.	37.3	21.5
1902	81.5	63.	77.1	57.3	72.5	52.9	63.4	45.1	59.1	40.8	37.4	22.6
1903	80.8	62.	79.6	60.5	75.9	52.5	63.0	43.6	44.4	28.1	30.9	16.1
1904	79.2	60.4	77.8	56.5	74.8	53.7	61.9	41.8	48.6	31.2	34.9	21.1
1905	81.7	60.5	79.6	54.0	73.6	54.7	66.4	43.4	46.8	31.6	39.1	27.0
1906	79.6	65.5	....	....	....	....	....	....	....	....	....	....
Max. and Min.	85.1	60.4	81.9	68.2	79.0	58.7	70.2	49.3	59.1	[illegible]	39.1	[illegible]

In Table VIII, the maximum and minimum daily average temperatures in the different months are given for seven years as recorded at the Wellsburg station. The coldest day in this period was in February, 1904, with a temperature of 12.9°, and the warmest day was 85.1° in July, 1901.

Plate XV.—a. Upper and Lower Clay Mines at the Etna Plant, New Cumberland.

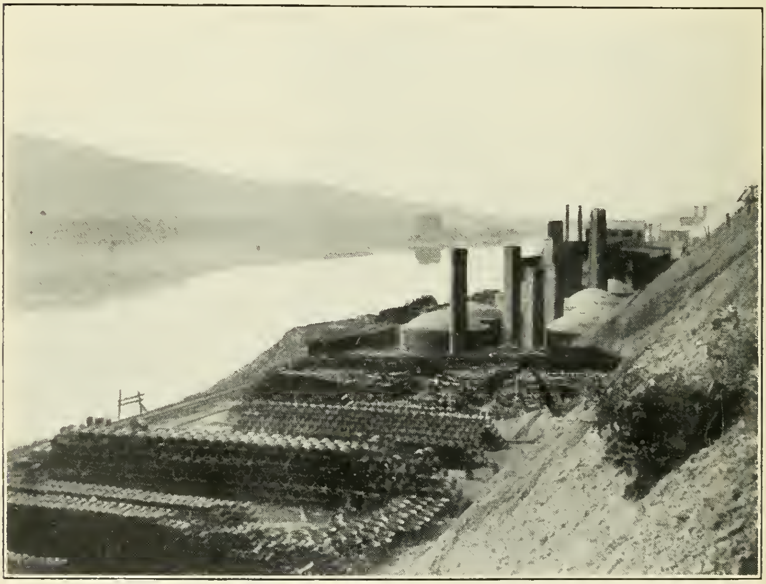

Plate XV.—b. Eagle Sewer Pipe Works, New Cumberland, Hancock County.

Table IX.—Number of Hot Days Over 90° at Wheeling.

	June	July	August	September	Total
1876	—	2	1	0	3
1877	0	0	0	0	0
1878	0	4	0	0	4
1879	0	2	0	0	2
1880	3	1	0	0	4
1881	0	4	0	3	7
1882	0	0	0	0	0
1883	0	4	0	0	4
1884	0	0	0	0	0
1885	0	3	0	0	3
1886	0	0	0	0	0
1887	0	9	3	0	12
1888	2	0	0	0	2
1889	0	1	0	0	1
1890	1	2	3	0	6
Average					3

Table IX shows the number of hot days when the daily average temperature was 90° or over at Wheeling for a period of 15 years, giving an average of three hot days a year for this period.

During four of these years there was no day in which the temperature reached 90°, while the greatest number of these days was 12 in 1887. This record will compare favorably with some of the mountain resorts. According to the Maryland Geological reports, the average number of hot days at Deer Park is four.

EARLY AND LATE FROSTS.

In table X the dates for the latest frost in the spring, and the earliest in the fall, are given for the three stations—Wheeling, Wellsburg, and New Cumberland. The frosts appear to come later in the spring and earlier in the fall as you go north from Wheeling to Wellsburg, but with very little difference between Wellsburg and New Cumberland. The distance from Wheeling to New Cumberland is 34 miles, with a difference of 342 feet altitude.

Table X.—Killing Frosts.

	WHEELING		WELLSBURG		NEW CUMBERLAND	
	Last in Spring	First in Autumn	Last in Spring	First In Autumn	Last in Spring	First in Autumn
1899	April 5	Oct. 1	....	Oct. 1	April 10	Oct. 1
1900	April 10	Nov. 14	May 10	Oct. 17	....	....
1901	April 1	Nov. 10	April 21	Oct. 4	....	....
1902	April 8	Oct. 22	May 10	Oct. 15	....	....
1903	April 5	Oct. 25	April 22	Oct. 25	May 2	Oct. 24
1904	April 21	Oct. 28	April 22	Sept. 22	April 22	Sept. 22
1905	....	Oct. 30	April 19	Oct. 29	May 23	Oct. 30
1906	May 7	Oct. 20	May 10	Oct. 10	May 8	Oct. 11

This table gives the following number of days between frosts at the three stations:

	Wheeling.	Wellsburg.	New Cumberland.
1899	179	---	174
1900	219	161	---
1901	224	167	---
1902	198	159	---
1903	204	187	176
1904	191	153	153
1905	---	194	161
1906	167	154	157
Average	197	168	164

SNOWFALL.

The records are not very complete for the annual snowfall, but those given in the reports of the U. S. Weather Bureau are grouped together in table XI, and show an interesting relation in that the snowfall for each year of the record was greatest at Wellsburg, half way between Wheeling and New Cumberland. It was greater at Wheeling than New Cumberland each year except 1906, where the record is incomplete.

Table XI.—Annual Snow Fall (Inches).

	Wheeling	Wellsburg	New Cumberland
1899	40.6	....	22.0
1900	23.5	29	....
1901	20.6	26	....
1902	43.0	52.8	....
1903	31.1	40.5	17
1904	24.1	39.2	22.5
1905	....	38.3	22.5
1906	20.5a	49.9	30.3
Average...	29.1	39.4	22.8

a. Incomplete.

RAINFALL.

Table XII shows the monthly and annual rainfall at Wheeling for over 14 years, with the average rainfall by months and years. The month of greatest rainfall was July, 1896, with 11.84 inches, and the least was October, 1901, with 0.12 inch. In only 11 months of the entire period has the rainfall been less than one inch.

The greatest annual rainfall was 45.38 inches in 1896, and the least was 28.4 inches in 1894. The rainfall was over 40 inches in six years of the period, 1893, 1896, 1897, 1898, 1901, 1902. The average amount of annual rainfall at Wheeling for the 15 years is 37.38 inches. July is the month of highest average rainfall, 4.61 inches; and September the month of least rainfall, 2.23 inches.

Table XII.—Monthly and Annual Rain Fall, Wheeling.

	Jan.	Feb.	Mar	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann'L
1891..........	....	....	....	....	....	....	.....	....	....	....	2.73	3.00	
1892..........	3.24	2.65	2.15	2.10	5.40	3.23	5.07	1.55	3.17	0.82	2.45	0.91	32.74
1893..........	2.09	5.89	1.39	5.69	4.36	4.67	2.36	4.51	1.05	5.13	1.70	3.33	42.17
1894..........	1.93	2.46	2.35	3.47	4.12	1.62	1.46	1.43	2.21	1.93	2.19	3.23	28.40
1895..........	4.91	0.40	2.35	2.19	1.32	2.08	4.51	3.56	1.90	1.92	2.51	3.85	31.60
1896..........	2.12	2.25	3.60	4.35	2.89	5.89	11.84	2.17	3.87	2.01	2.62	1.77	45.38
1897..........	1.21	3.85	4.27	4.31	4.58	3.22	5.69	2.14	0.85	0.70	6.93	3.79	40.91
1898..........	5.00	2.40	5.70	3.62	3.69	2.89	5.72	2.14	3.46	3.97	2.45	2.68	43.72
1899..........	2.81	2.86	4.36	2.29	3.69	4.76	3.51	1.20	2.74	2.47	2.21	2.40	35.30
1900..........	1.83	3.15	2.71	1.76	2.69	3.20	4.26	2.36	0.75	1.23	4.88	1.55	30.37
1901..........	1.39	0.70	3.43	8.73	5.50	6.05	2.30	3.80	4.11	0.12	1.76	4.55	42.50
1902..........	1.58	1.42	3.56	3.51	1.97	7.50	5.50	3.56	3.04	2.69	1.70	4.71	40.74
1903..........	1.99	5.24	4.89	3.71	2.05	6.52	2.06	1.69	0.57	3.83	2.05	1.82	36.42
1904..........	2.03	4.51	3.82	2.68	4.52	2.92	5.81	2.52	0.80	1.52	0.27	1.43	32.83
1905..........	1.25	1.65	5.58	3.44	4.38	5.86	3.23	3.03	2.17	3.32	3.01	1.25	38.17
1906..........	1.36	0.70	1.98	2.38	1.16	5.81	5.75	4.36	2.73	2.50	0.75	3.10	32.58
Av. Rain Fall.	2.34	2.70	3.50	3.61	3.49	4.41	4.61	2.67	2.23	2.28	2.51	2.71	37.38

Figure 32 illustrates the variation in annual rainfall at Wheeling for 15 years, and figure 33 shows the minimum and maximum amounts of monthly rainfall as compared with the average.

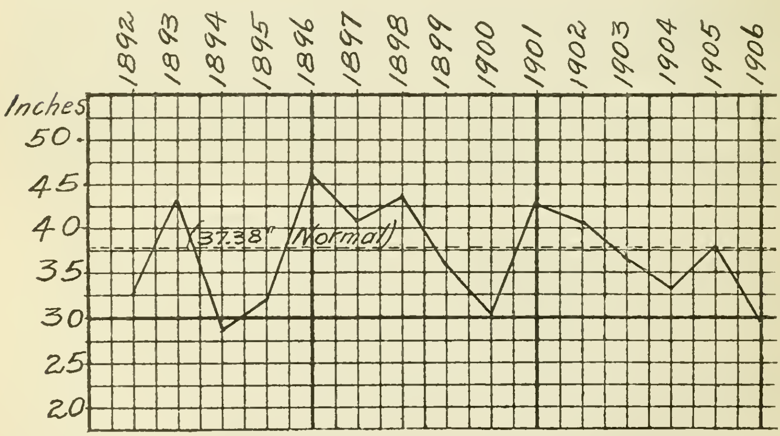

Fig. 32.—Variations in mean annual rainfall at Wheeling, 1892—1906.

Fig. 33.—Monthly rainfall at Wheeling (15 years).
a.—Maximum.
b.—Average.
c.—Minimum.

Table XIII gives the monthly and annual rainfall at Wellsburg for seven years. In this period the average annual rainfall is 43.95 inches, with the greatest, 43.65 inches, in 1906, and the least, 33.94 inches, in 1900. The greatest monthly rainfall was 9.32 inches in June, 1906, and the least, 0.26 inches, in October, 1901. The highest monthly average was 5.75 inches in June, and the lowest, 2.19 inches, in November.

Table XIII.—Monthly and Annual Rain Fall, Wellsburg.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann'l.
1900	2.08	3.22	3.04	2.08	1.04	4.65	6.13	4.11	1.24	1.16	3.75	1.44	33.94
1901	1.75	0.81	2.81	8.24	6.81	4.97	3.53	4.16	3.67	0.26	1.82	4.63	38.46
1902	2.68	2.92	3.32	3.53	2.28	6.88	4.44	2.37	3.76	3.30	1.74	5.11	42.33
1903	2.94	5.33	5.20	3.60	2.17	5.73	5.24	2.03	1.13	2.77	3.36	2.35	41.85
1904	2.71	2.16	4.97	2.91	4.26	4.91	5.92	2.15	1.34	3.02	0.58	3.05	37.90
1905	3.34	1.76	2.46	1.86	5.13	4.85	3.26	2.69	3.99	2.48	2.89	3.17	37.82
1906	2.29	1.13	3.27	2.21	2.03	9.32	5.45	6.53	4.32	3.50	1.30	3.47	44.82
Average	2.54	2.49	3.55	3.49	3.39	5.75	4.94	3.43	2.78	2.35	2.19	3.15	43.95

Table XIV shows the monthly and annual rainfall at the New Cumberland station for six years. In this period the average annual rainfall was 37.63 inches, with the greatest in 1905, 42.53 inches, and the least, 33.95 inches, in 1902. The greatest monthly rainfall was 8.3 inches in April 1901, and the least 0.1 inch, in February, 1901. The highest monthly average was 6.12 in June; and the lowest, 1.45 inches, in November.

Plate XIV.—Monthly and Annual Rainfall, New Cumberland.

	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Ann'l.
1901	....	0.10	4.27	8.30	5.30	6.53	2.86	4.34	2.72	0.35	1.70	4.03	41.50
1902	1.20	1.28	2.97	1.68	2.08	7.07	5.77	3.25	1.61	2.45	1.24	3.35	33.95
1903	2.00	4.70	3.40	2.72	1.88	4.57	2.51	5.02	1.11	3.10	2.39	1.97	35.37
1904	3.30	1.85	5.60	2.42	3.48	4.57	4.17	3.60	1.62	1.25	0.55	2.25	34.66
1905	1.48	2.87	3.15	2.38	6.30	6.70	4.10	2.73	4.15	4.40	2.17	2.10	42.53
1906	1.40	0.75	3.04	2.10	3.05	7.30	6.70	4.68	3.10	3.02	0.67	1.83	37.64
Average	1.87	1.92	3.74	3.26	3.68	6.12	4.33	3.93	2.38	2.43	1.45	2.61	37.63

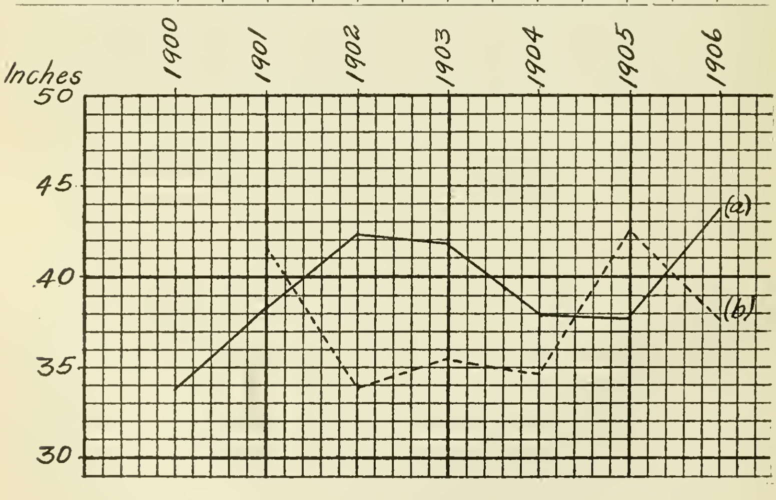

Fig. 34.—Variations in mean annual rainfall, 1900—1906.
a.—Wellsburg.
b.—New Cumberland.

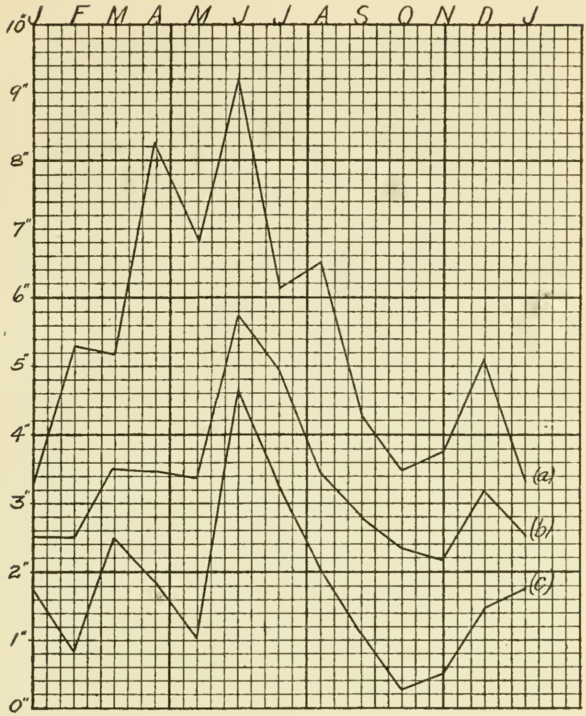

Fig. 35.—Monthly rainfall at Wellsburg (7 years).
a.—Maximum.
b.—Average.
c.—Minimum.

Figure 34 illustrates by curves the variations in mean annual rainfall at Wellsburg and New Cumberland. Figure 35 shows by curves the maximum, minimum, and average monthly rainfall at Wellsburg, while figure 36 illustrates the same at New Cumberland.

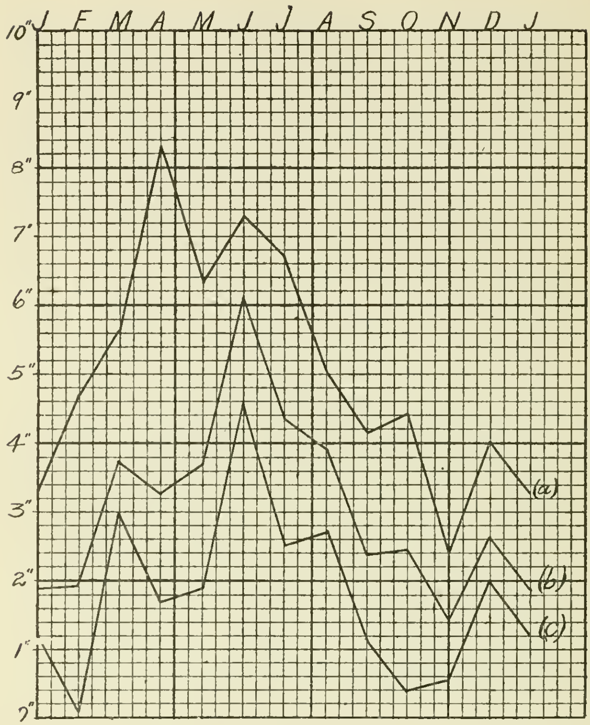

Fig. 36.—Monthly rainfall at New Cumberland (6 years).

a.—Maximum.
b.—Average.
c.—Minimum.

FAIR, CLOUDY, AND RAINY DAYS.

Tables XV A and B have been compiled from the records of Mr. Schnepf at Wheeling, and show the number of fair, cloudy, and rainy days. In these records the observer marked as rainy days those in which most of the day was rainy, while days with local showers or showers of short duration were classed with cloudy days. The reader must therefore remember that months marked with no rainy days were not therefore without rain, though usually such months had a low rainfall.

Table XV-A.—Fair, Cloudy, and Rainy Days at Wheeling.

*and Snow	January			February			March			April			May			June		
	Fair	Cloudy	Rain*	Fair	Cloudy	Rain*	Fair	Cloudy	Rain*	Fair	Cloudy	Rain*	Fair	Cloudy	Rain	Fair	Cloudy	Rain
1878.	13	5	13	12	5	13	13	1	17	15	4	11	12	12	7	17	5	8
1879.	16	7	8	11	4	13	15	8	8	19	5	6	23	4	4	19	1	10
1880.	13	9	9	17	6	6	15	11	5	13	7	10	26	2	3	16	10	4
1881.	14	7	10	17	2	9	10	8	13	12	10	8	23	5	3	18	6	6
1882.	9	7	15	11	6	11	13	11	7	18	7	5	16	7	8	17	9	4
1883.	16	8	7	14	7	7	17	7	7	17	3	10	19	12	0	19	11	0
1884.	12	8	11	11	9	9	12	8	11	15	12	3	18	12	1	24	3	3
1885.	14	5	12	19	2	7	13	10	8	13	4	13	13	11	7	21	9	0
1886.	16	8	7	17	9	2	16	7	8	19	5	6	17	13	1	18	6	6
1887.	10	15	6	9	10	9	17	9	5	17	11	2	23	6	2	22	4	4
1888.	11	14	6	15	12	2	14	12	5	18	12	0	14	16	1	19	11	0
1889.	16	14	1	18	9	1	16	12	3	15	15	0	16	15	0	10	20	0
1890.	11	17	3	13	15	0	12	17	2	20	9	1	12	19	0	12	18	0
1891.	9	20	2	10	16	2	13	17	1	20	8	2	18	12	1	19	11	0
1892.	11	4	16	10	3	16	14	2	15	15	1	14	8	1	22	13	2	15
1893.	7	4	20	8	5	15	16	2	13	12	2	16	15	2	14	19	0	11
1894.	19	4	8	13	3	12	20	3	8	15	4	11	11	0	20	22	0	8
1895.	8	5	18	16	5	7	16	2	13	18	4	8	20	5	6	22	3	5
1896.	12	8	11	8	6	15	15	5	11	20	1	9	19	3	9	13	2	15
1897.	11	11	9	10	8	10	15	2	14	14	4	12	15	4	12	18	6	6
1898.	10	10	11	11	7	10	15	4	12	17	3	10	14	4	13	21	2	7
1899.	13	10	8	13	7	8	14	6	11	20	4	6	16	5	10	18	6	6
1900.	12	7	12	15	2	11	17	5	9	19	3	8	20	5	6	17	2	11
1901.	12	3	16	14	7	7	17	4	10	14	3	13	16	2	13	18	4	8
1902.	13	10	8	16	4	8	18	5	8	16	5	9	23	3	5	19	0	11
1903.	13	12	6	9	17	2	12	17	2	13	15	2	22	9	0	12	16	2
1904.	11	13	7	14	15	0	11	20	0	11	19	0	17	14	0	17	13	0
1905.	16	11	4	15	11	2	17	13	1	14	16	0	15	16	0	16	14	0
1906.	16	14	1	18	9	1	10	13	8	...	...	...	...	...	...	...	...	...

Table XV-B.—Fair, Cloudy, and Rainy Days at Wheeling.

*and Snow	July			August			September			October			November			December		
	Fair	Cloudy	Rain	Fair	Cloudy	Rain	Fair	Cloudy	Rain	Fair	Cloudy	Rain*	Fair	Cloudy	Rain*	Fair	Cloudy	Rain*
1878.	21	2	8	18	7	6	17	6	7	19	4	8	16	5	9	6	9	16
1879.	21	4	6	17	10	4	22	5	3	18	6	7	12	8	10	9	11	11
1880.	21	8	2	20	3	8	20	4	6	12	11	8	12	10	8	11	13	7
1881.	24	6	1	28	2	1	24	2	4	18	6	7	14	8	8	10	8	13
1882.	20	8	3	18	6	7	17	7	6	25	3	3	15	6	9	13	12	6
1883.	22	8	1	26	5	0	14	11	5	16	9	6	13	12	5	12	10	9
1884.	25	3	3	24	5	2	19	9	2	19	7	5	17	7	6	13	9	9
1885.	23	6	2	18	8	5	21	4	5	16	7	8	13	11	6	16	9	6
1886.	22	7	2	20	11	0	19	7	4	23	6	2	15	3	12	16	6	9
1887.	21	10	0	20	11	0	16	12	2	18	12	1	15	11	4	15	12	4
1888.	20	10	1	19	10	2	19	9	2	11	19	1	13	16	1	14	15	2
1889.	22	9	0	22	9	0	18	9	3	16	13	2	11	13	6	15	15	1
1890.	24	7	0	21	9	1	13	17	0	8	21	2	17	13	0	17	11	3
1891.	19	10	2	18	13	0	21	9	0	19	11	1	14	12	4	17	4	10
1892.	18	0	13	22	2	7	23	1	6	20	6	5	10	7	13	12	10	9
1893.	21	0	10	25	0	6	23	2	5	19	4	8	17	3	10	12	5	14
1894.	26	1	4	22	3	6	23	4	3	19	4	8	13	2	15	14	5	12
1895.	19	4	8	23	2	6	20	4	6	24	3	4	14	4	12	13	6	12
1896.	11	2	18	20	5	6	20	2	8	17	6	8	12	6	12	14	9	8
1897.	19	3	9	21	4	6	27	0	3	23	6	2	12	2	16	11	6	14
1898.	14	3	14	21	2	8	21	2	7	17	4	10	15	5	10	15	4	12
1899.	19	6	6	24	2	5	19	4	7	21	5	5	20	0	10	13	4	14
1900.	21	0	10	22	3	6	25	2	3	27	2	2	10	7	13	14	10	7
1901.	22	2	7	21	4	6	20	2	8	25	3	3	10	10	10	15	7	9
1902.	21	0	10	22	3	6	17	3	10	17	7	7	8	21	1	1	21	9
1903.	13	12	6	20	11	0	25	5	0	18	3	10	13	16	·1	13	15	3
1904.	19	12	0	16	15	0	25	4	1	23	8	0	20	9	1	9	18	4
1905.	19	12	0	19	12	0	24	6	0	16	14	1	17	12	1	17	13	1
1906.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

According to these tables, July, 1904 and 1905, had no days with rain through most of the time, yet the rainfall for July, 1904, was 5.8 inches, and for July, 1905, 3.23 inches, due to local heavy showers.

The average conditions from the preceding tables XV-A, XV-B, for the 29 years are given in table XVI, which shows 199 clear days in the year at Wheeling and 166 cloudy and rainy days, and is illustrated by figure 37.

Table XVI.—Average Weather Conditions at Wheeling for 29 Years.

	Jan.	Feb	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov	Dec.	Ann'l.
Fair	13	13	14	16	18	18	20	21	20	19	14	13	199
Cloudy ...	9	8	9	7	7	7	6	6	6	7	9	10	91
Rain	9	7	8	7	6	5	5	4	4	5	7	8	75

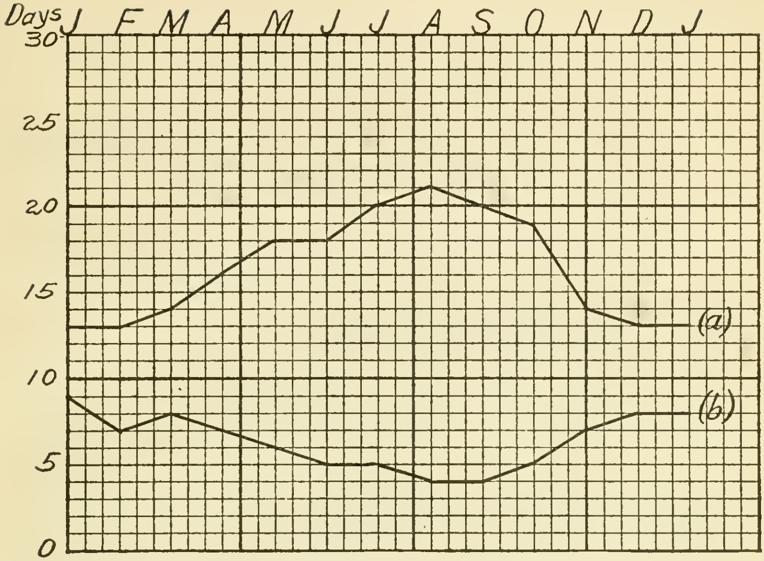

Fig. 37.—Average number of fair and rainy days at Wheeling for 29 years.

a.—Fair days.
b.—Rainy days.

WIND DIRECTION.

The prevailing direction of the wind at Wheeling is northwest; and at Wellsburg, west. At New Cumberland, with but few records available, the direction is west and south.

CHAPTER XII.

SOIL SURVEY OF THE PAN HANDLE COUNTIES, WEST VIRGINIA.

By Thomas A. Caine and G. W. Tailby, Jr.[1]

DESCRIPTION OF THE AREA.

The Wheeling area comprises the northern part of that section of West Virginia known as the Panhandle, and includes the whole of Hancock, Brooke, and Ohio counties and the northern part of Marshall county. It is bounded on the north and west by the Ohio river, on the east by Pennsylvania, and on the south by parallel 40° north latitude. In a north and south direction it has a length of 45 miles, while its width varies from about 4½ to 12 miles. The area is included within meridians 80° 30′ and 80° 45′ west longitude and parallels 40° and 40° 40″ north latitude.

When viewed from the Ohio river the area presents a hilly and rugged appearance. The river valley is gorge like, the bottom land along the river being very narrow and in many places entirely lacking, and the stream is often bordered by steep, angular hills varying in elevation from 300 to 600 feet. The altitude of the Ohio river is about 615 feet above sea level. Proceeding back from the river a mile or so it is seen that the region is better adapted for agriculture than at first appeared. The Ohio valley is scarcely noticeable at that distance, and the tops of the hills in all directions as far as can be seen are of the same general level. These are the remnants of an ancient upland plain which has been dissected by ages of erosion. The general altitude of these uplands varies from 1,100 to 1,300 feet. The surface, however, sometimes rises 100 feet or more above the general level, and viewed from one of these high points the whole region resembles a mountainous country in miniature. The highest point

1. U. S. Department of Agriculture, Bureau of Soils, in co-operation with the West Virginia Geological Survey. Published by permission of Prof. Milton Whitney, chief of Bureau of Soils.

in the area is in Marshall county, and has an altitude of 1,476 feet, so that there is a total range in elevation within the area of 850 feet. The drainage of the area is all toward the Ohio river, and the channels of the larger streams lie deeply intrenched in narrow, steep-sided valleys from 300 to 500 feet below the level of the upland plain. The valleys of the smaller tributary streams are also steep sided and vary in depth from 50 to 300 feet. The floors of these valleys are seldom wide enough to permit the accumulation of sediments along the streams, for which reason there is little bottom land in the area. In some places the valley floors are so narrow that the stream bed is utilized as a road. The many ravines dissecting the area have made much of the region unfit for general farming, but this is partly compensated for by the fact that the deep erosion has exposed beds of coal and fire clay, which are being mined with profit.

The first permanent settlers in the area came from Virginia, Maryland, and North Carolina, and located in the vicinity of West Liberty in 1772. Soon afterwards more colonists came and located near Wellsburg and Wheeling. When the original thirteen States were organized the Panhandle fell within the territory of Virginia and remained a part of that State until the formation of West Virginia in 1863.

Ohio county was organized in 1785 and at that time included not only all of the Panhandle, but extended indefinitely westward. In 1797 Brooke county was separated from Ohio county. At that time it included all of what is now Brooke and Hancock counties, and also extended westward over an indefinite territory. After the formation of the State of Ohio the westward extension of these counties became fixed by the Ohio river. In 1848 the northern end of the Panhandle became more thickly settled and Hancock county was separated from Brooke county.

The additions to the population were considerable during the first fifty years following 1772. Among those who came were a few Germans and many Scotch and Irish. The majority of the settlers, many of them men of education and refinement, came from eastern Virginia and brought with them the customs and manners of that locality.

Until about twenty years ago little had been done to develop the natural resources of the area. Coal, natural gas, and

fire clay are now being utilized, and numerous potteries, glassware factories, brick works, tin mills, and blast furnaces are in operation. There has been a great increase in population, and the old towns have increased in size and many new ones have sprung up. At present only about 30 per cent of the population of the area are engaged in agricultural pursuits. The original forest growth of the region has practically all been removed, and all of the region not too steep for general agricultural purposes is cleared and in cultivation.

The chief towns of the area are Wheeling, Wellsburg, New Cumberland, and Chester, all located on the banks of the Ohio. Across the river in Ohio, East Liverpool, Wellsville, Steubenville, Martins Ferry, and Bellaire are important cities, and are connected with the West Virginia side by railroads, trolleys, and ferries. There are numerous other smaller towns within the area that are important from a manufacturing standpoint. These cities and towns furnish a greater demand for general farm and dairy products and truck crops than is at present being supplied by the agricultural population of the area.

The superior shipping facilities afforded by the Ohio river have always been an important factor in the development of the region, and at present there are numerous landings along the western side of the area where products can be loaded on the steamers. The area is now also well supplied with steam railroads and electric lines. The "Panhandle" line, a part of the Pennsylvania system, extends along the banks of the Ohio from Wheeling to Chester. Another line extends the full length of the area on the other side of the river. The main line of the Pennsylvania railroad crosses about the middle of the area through Harmon creek, and the Wabash crosses a little south of this. A branch of the Baltimore & Ohio crosses the southern part of Ohio county and connects Pittsburg with Wheeling, which now has considerable importance as a railway center. A trolley line connects Wheeling with Steubenville, Ohio, passing through Wellsburg, W. Va., and another one passes through Wheeling Creek Valley from Wheeling to State Line at West Alexander, Pa. These all carry passengers, baggage, freight, and dairy products.

CLIMATE.

The climate of the Wheeling area is healthful and well suited to the carrying on of general farming. The winter weather is cold, and often there is considerable snow, but it can not be said that the winters are very severe. It is seldom that the mercury goes below zero, and the average for the three coldest months—December, January, and February—is about 28° F. The summers are warm and pleasant, and the mercury seldom goes as high as 100° F. The average for the three hottest months—June, July, and August—is about 72° F.

The average annual rainfall for the area is about 40 inches. The least precipitation occurs in October, after the close of the growing season, while the greatest precipitation occurs in June and July, when the growing crops need it most. The average length of the growing season is six and one-half months, and stock can be pastured for about seven months.

The following tables give the normal monthly and annual temperature and precipitation for the area as shown by the Weather Bureau records at Demos, Ohio, and at New Martinsville, W. Va., and the dates of the earliest and latest killing frosts, as shown by records at Wheeling, W. Va.:

Normal Monthly and Annual Temperature and Precipitation.

Month	Demos, Ohio		New Martinsville. W. Va.		Month	Demos, Ohio.		New Martinsville, W. Va.	
	Temperature.	Precipitation.	Temperature.	Precipitation.		Temperature.	Precipitation.	Temperature.	Precipitation.
	°F.	Inches	°F	Inches		°F.	Inches	°F.	Inches.
Jan. ...	27.5	2.66	32.0	3.12	Aug. ..	72.4	3.40	74.1	2.93
Feb. ...	26.0	3.16	30.6	2.96	Sept. ..	66.3	2.55	68.0	2.42
March .	39.6	3.61	42.7	3.32	Oct. ..	53.9	1.97	56.0	2.09
April ..	49.5	3.14	52.9	3.44	Nov. ..	41.8	2.37	44.1	3.35
May ...	62.4	3.23	63.6	3.54	Dec. ...	30.3	2.88	34.8	3.19
June ...	69.9	4.21	72.1	3.85					
July ...	73.6	4.88	72.8	5.42	Year.	51.1	38.06	53.6	39.63

Dates of First and Last Killing Frosts.

Year	Wheeling		Year	Wheeling	
	Last in spring.	First in fall		Last in spring	First in fall.
1897	Apr. 20	Oct. 30	1902	Apr. 8	Oct. 22
1898	Apr. 8	Oct. 28	1903	Apr. 5	Oct. 25
1899	Apr. 5	Oct. 1	1904	Apr. 21	Oct. 28
1900	Apr. 10	Nov. 14			
			Average....	Apr. 11	Oct. 26

AGRICULTURE.

The early settlers found the virgin soils well adapted to grain, particularly wheat, corn, and rye, and the growing of these crops constituted the main type of farming for the first fifty years following 1772. The production of these crops was far in excess of the local demands, and upon the establishment of river transportation with the older colonies on the lower Mississippi a large flour trade was developed. Distilleries were built in connection with the flour mills and the corn and rye were marketed at the mills and converted into whisky.

By 1840 grain growing is said to have become unprofitable because of the constant cropping of the soils under careless methods. The wheat yields, it is stated, had fallen off year after year from 35 bushels to about 10 bushels per acre, and other grain crops had decreased in like proportion. Considerable land was abandoned as "worn-out" and allowed to grow up to weeds and brush, and for a time grain growing was so far abandoned as scarcely to supply the local demands. Another, and perhaps the most influential, cause of the decrease in grain production was the fact that the hill farmers of the area were not able to compete with the farmers on the level virgin soils of the West.

About this time it was thought that sheep raising could be carried on with profit, and in 1835 a number of Merino and Saxony sheep were imported from Europe. The industry was so profitable that it spread in all directions and became very important in Virginia, Ohio, and Pennsylvania. Nearly every farmer kept some sheep, and a number of those who had large flocks became quite wealthy. The wool answered the commercial requirements of the time, since it was not exceedingly bulky, could be handled easily, was nonperishable, easily shipped, and brought

ready cash. The wool or the manufactured woolen products were readily exchanged in the Southern markets for sugar, molasses, cotton, and fruits.

For a number of years sheep raising was the most important industry in the area and little attention was paid to other lines of agriculture. It was found that after being pastured to sheep for a number of years the "worn-out" soils were greatly benefited and some claim that they became more productive than ever. By this time the whole country had made marked progress in settlement, and with the increase of population there arose a great demand for all kinds of farm produce, especially dairy products and fruit and truck crops. A reduction in the price of wool caused sheep raising to become somewhat unpopular and the wool industry no longer constitutes the principal pursuit. However, it is an important auxiliary to general farming, especially among the most progressive and prosperous farmers, who use this means of maintaining the productivity of their soils.

There has been an increase in the acreage of wheat, corn, and oats, and in parts of the area the production of apples has assumed considerable importance. Some of the farmers are striving to supply the increasing local demands for milk and butter, fruit of all kinds, and truck crops. Many of the orchards in close proximity to the brick and tile works along the river have been greatly damaged by gas and smoke, and the influence of this is noticeable for a mile or so back from the river. In places the native vegetation has all been killed and the steep, rough hills above the manufacturing plants present a barren aspect.

It is recognized that the upland areas are well adapted to the dairy business, but owing largely to the confining nature of the occupation and the lack of intelligent labor to handle the stock, as well as the steep, rough roads to market, this industry is limited mostly to farms convenient to towns. It is also recognized that the upland areas, especially those having soils of sandstone origin, are well adapted to truck crops and fruit, but owing largely to inaccessibility to markets the trucking industry is largely confined to the level sedimentary soils along the Ohio river and its larger tributaries. The fact that the important local markets are along the river and the roads are good makes this class of soils very profitable for trucking purposes. These sedimentary soils are also

well adapted to general farm crops, but they are more profitable for trucking. Owing to the demand for factory, manufacturing, and town sites in recent years, the extent of the sedimentary soils used for trucking is becoming more and more limited.

On the upland farms the steep hillsides are usually fenced off from the tillable part of the farm and kept in permanent pasture, some of which have been standing for over forty years. The customary system of rotation upon the tillable upland farms is one year each of corn, oats, and winter wheat. What few potatoes are grown on these farms are planted in small patches in the cornfields. Timothy is sown in the fall with the wheat, and clover is sown the following spring. The first year the meadow consists largely of clover, but the next year the timothy predominates. The field is permitted to stand in timothy as long as it will yield a profitable crop, usually from three to five years. On the limestone soils as the timothy thins out Kentucky blue grass comes in. The latter is never cut for hay, but makes fine pasturage. The length of time a field remains in pasture depends upon the size of the farm, the amount of stock kept, and somewhat upon the character of the soil. The most successful farmers try to keep land seeded down as long as possible and keep enough stock to consume the greater part of the hay, straw, and grain. Some grow corn for two successive years and then follow the usual rotation. There are only three custom flour mills in the area, and practically all of the farmers sell their wheat and buy flour imported from other States. This has led some to abandon wheat growing and to substitute a yearly rotation of corn and oats. Timothy and clover are sown in front of the drill with the oats, and usually two excellent crops of clover are secured the following year. There are a few farmers who do not keep stock, but depend upon the renovating effect of the clover to keep the soil in good condition. Again, there are a few farmers who follow the usual system of rotation, but instead of keeping an abundance of stock and turning the sod as seldom as possible they shorten rotations to four or five years and sell off all available grain, straw, and hay, and depend upon the use of commercial fertilizers to keep up the crop yields. In the trucking areas no rotation is practiced. These level areas are not subject to erosion,

and their productivity is maintained by occasional overflows and the application of manure obtained from the livery stables.

The great demand for truck in the Wheeling markets has led some to engage in trucking on the hilltops 600 or 700 feet above the town. Usually the truckers haul manure from town and do not follow any rotation, except in cases where it is imposible to get sufficient manure. Then they put in a crop of wheat and seed the ground to grass for a few years.

The adaptation of the methods to the present conditions on the rolling uplands is well illustrated in the case of the corn crop, practically the only clean cultivated general farm crop in the area. The soil is plowed to a depth of about 7 inches, and the corn is either drilled or dropped in rows running with the contour of the hills so as to keep erosion in check.

The low prices paid for wool, the rapid industrial development of the region, and the increased demands for agricultural products have completely changed the agricultural conditions during the past quarter of a century. As a whole the farmers south of Kings Creek are quite prosperous, as is shown by the low percentage of mortgaged farms. Their dwellings and barns are usually quite substantial, they are well supplied with good draft horses, and there is an abundance of up-to-date farm machinery in use. In recent years the sale of coal, oil, and gas rights has brought much wealth to the farming class.

The great demand for laborers in the factories, mills, potteries, blast furnaces, and mines, has attracted many people from adjoining States, and many of the young men have left the farms for the towns, where they have shorter hours of work and better pay. The scarcity of good farm labor is one of the most serious drawbacks to farming. The wages paid farm hands range from $20 to $30 a month with board, lodging, and washing, and feed for a driving horse. The most progressive farmers feel the necessity of arranging their farm practice in such a way as to get along with as little labor as possible. About 60 per cent of the farms are operated by the owners, the remainder being rented for cash or on shares. The average size of the farms is about 100 acres. The size of the holdings, however, ranges from a few acres to 500 acres.

There has been a great increase in the selling price of farm lands within the last twenty years. Farm lands without the coal rights are now bringing as much as they did twenty years ago with the coal rights. The average price of land throughout the area is about $50 an acre without the coal rights. The price varies considerably, depending upon the kind of soil and the convenience of the farm to town. Many of the wage-earning population of the area have built houses along the little runs and branches back from the Ohio river, where building sites can be obtained cheaply, and the problem of getting to and from their work has been solved by the trolley systems.

At present the live stock interests of the area are not as important as at times in the past. Some cattle, sheep, and hogs are kept by the farmers, but on most farms the number of animals could be profitably increased. The animals are of good quality, including the farm horses, which are well bred and cared for.

Until about twenty-five years ago the production of wool and mutton was one of the most important pursuits of the farmer. Since then the drop in the price of wool, together with losses from dogs, has caused so many farmers to cease sheep raising that now the number of sheep is reduced at least two-thirds. The most sheep were kept in Ohio and Brooke counties, where the Wheeling clay loam gives permanent blue grass pastures, which favor the profitable production of wool and mutton.

Only fine-wooled sheep, the Delaines and Merinos, are raised. These give a good yield of wool, besides the lambs, which are marketed in the fall and bring from $2 to $3 a head when six months old. It is believed that the number of sheep could be profitably increased on the Wheeling clay loam, where protection from dogs can be had.

The dairy interests are confined almost exclusively to the territory immediately surrounding the cities and villages. Within a radius of three miles of Wheeling nearly every farm maintains a dairy of from 10 to 50 cows, the average being 20. Little fine-bred stock is kept. A few farmers within five miles from the city retail their milk daily. Others along the trolley lines send their milk to wholesale dealers in the city. Milk retails at 8 cents a quart winter and summer, and at wholesale prices

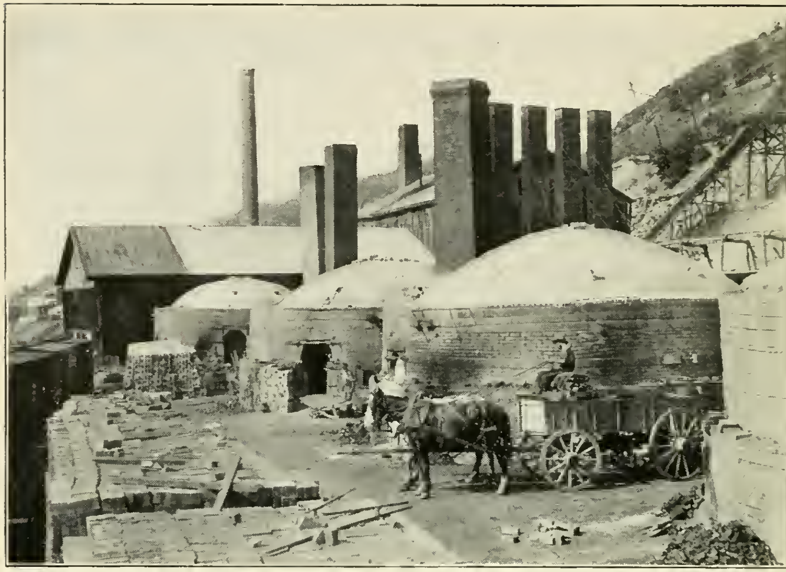

Plate XVI.—a. Down Draft Kilns at the Crescent Yard, New Cumberland, Hancock County.

Plate XVI.—b. Clifton Sewer Pipe Yard, New Cumberland, Hancock County.

brings from 15 to 18 cents a gallon. In Wheeling the legal standard for milk is 3 per cent of fat, a standard which is easily maintained by the farmers. At present the local supply of milk does not meet the demand and milk is shipped in from a distance.

Some farmers have found the production of beef profitable, and send into the city annually 5 or 6 or more fat steers. For farms too remote from towns for profitable milk production, and not well adapted to sheep raising, the production of beef is especially to be recommended. By this means the roughage produced on the farm may be turned into money and the productivity of the soil maintained. Only a few hogs are raised, but wherever corn is grown it is believed they can be raised at a profit.

SOILS.

The soils of the area fall naturally into three general divisions, each of which is represented by one or more different soil types. The first and most important are the residual upland soils, which occupy about 90 per cent of the area and are found in all locations from the gently rolling hilltops to the steepest hillsides. Geologically the upland portion of the area belongs to the Coal Measures of the Carboniferous age, and that portion of the Coal Measures here represented belongs to the Allegheny, the Conemaugh, the Monongahela, and the Dunkard series (Permian). Seven upland soil types were found, each differing from the others in texture, topography, and agricultural value.

The Conemaugh series is composed largely of fine-grained sandstone and sandy shale, and where the topography is gently rolling or moderately hilly it weathers into the Dekalb silt loam, while where the surface is hilly and steep the soil has been mapped as steep broken land. The Monongahela is composed of limestone, calcareous shale with some sandstone, and where the topography is rolling or moderately hilly it weathers into the Brooke clay loam. The Dunkard is composed of both sandstones and limestones, and weathers into the Dekalb silt loam, the Dekalb loam, and the Brooke clay loam, according to the character of the underlying rock.

The soils of limestone origin are recognized as the best and most durable for wheat, corn, oats, hay, and pasture, and are especially adapted to supporting a permanent blue grass pasture.

The soils of sandstone origin are not as durable and productive for general farming as those derived from limestone. Both kinds are used for the same crops, however, though the yields are greater upon the limestone than upon the sandstone soils. Where the two classes of soil occur together and somewhat mixed the difference is not so noticeable, but where found typically developed in widely separated parts of the area the difference is marked. This is indicated by the fact that in Hancock county, where the soils of sandstone origin predominate, about 20 per cent of the farms are mortgaged, while in Ohio county, where the limestone soils are well developed, not more than 5 per cent of the farms are mortgaged.

The second of the three general divisions of soils is found in the valley of the Ohio river, and occurs in the form of terraces. The material forming these terraces is reworked debris brought from the north during the Glacial epoch. The material is composed largely of sand and gravel, with considerable quantities of well-rounded stones, varying from 2 to 10 inches in diameter. This gives rise to two soil types, the Wheeling gravelly loam and the Wheeling sandy loam, depending upon the original assortment of the sand and gravel.

The third of the three general divisions of soils found in the area comprises the recent alluvial deposits in the valleys of the Ohio river and its larger tributary streams. The resulting soil types are the Huntington fine sandy loam and the Huntington loam. The former type occurs in narrow strips bordering the river and represents areas where the coarser materials, such as sand and vegetable matter, were dropped in flood time. The Huntington loam is usually found farther away from the stream, in areas where the finer materials, like clay, silt, and fine sand, were deposited from quieter currents. In the Ohio valley these two soil types occur as a veneer over the sandy and gravelly terrace materials discussed above. This is shown by excavations at Chester, New Cumberland, Wellsburg, and Wheeling.

The bottoms of all the smaller tributary streams are narrow and the streams are rapidly cutting their channels to the level of the Ohio river, very little energy being spent in widening them. Only in places are there patches of soil, and these are usually too small to be shown upon a map of the scale used. Along the bot-

toms of the larger tributary streams, such as Short, Cross, and Wheeling creeks, there is a considerable area of bottom land. The channels of these streams are nearly down to the level of the Ohio river and the valleys in places are a half mile or more in width. The bottoms are all subject to overflow, and the soil found there, though rather variable in texture, is a loam having the characteristics of the Huntington loam.

The following table gives the names and the actual and relative extent of the different soil types:

Areas of Different Soils.

Soil	Acres	Per cent.	Soil	Acres	Per cent.
Steep broken land..	56,448	28.0	Huntington fine sandy loam......	1,536	0.8
Rough stony land...	41,856	20.8	Wheeling gravelly loam	1,472	.7
Broken clay loam...	38,080	18.9	Upshur clay.......	704	.3
Dekalb loam........	27,008	13.4	Wheeling sandy loam	576	.3
Dekalb silt loam....	23,424	11.6			
Huntington loam....	8,576	4.2			
Dekalb sandy loam..	1,920	1.0			
			Total...........	201,600	....

Steep Broken Land.

The soil of the steep broken land, which is often a silty or heavy loam, varies in depth from a few to about 10 inches. The color ranges from brown to light brown. The subsoil usually contains considerable clay, enough to make it a clay loam, and in some instances almost a clay. Scattered upon the surface and throughout both soil and subsoil are found fragments of shale and sandstone, and often the solid rock is reached at a depth of a few feet. Where the sandstone formations are prominent the fragments become quite numerous, those upon the surface being plentiful enough to interfere with cultivation. This type is not often cultivated, and where it is, it requires very careful attention, and the crops have to be sown and gathered by hand.

This is one of the most widely distributed soils encountered and is especially well developed in the northern part of the area in connection with the Conemaugh series of rocks, which consist largely of soft marly and sandy shales. These shales weather rapidly and produce long and rather steep slopes. The type is

also well developed in the southern part of the area in connection with the upper part of the Dunkard series of rocks, where some of the conditions of rock texture and structure are similar to those of the Conemaugh series. It is less well developed in the middle part of the area, where the Monongahela series and the base of the Dunkard occur. In these, either limestones or shales predominate, which weather into gentler slopes and form another type of soil.

The steep broken land is made up wholly of slopes which are too steep for convenient tillage, and on which the drainage is excessive. The soil is residual and derived from the weathering of soft marly and sandy shales, which are the most extensive of any of the rocks in the area. The fine-grained sandstones which occur interbedded with the shales also enter into its formation.

These areas were originally covered with a growth of hardwoods, practically all of which has long been removed. As they are too steep for convenient tillage about 80 per cent is used for grazing. Very often the steepest and roughest parts of the pasture fields are permitted to grow up to locust thickets, which furnish very durable posts. Near the towns, where the dogs have become very troublesome to sheep, some of the farmers are cultivating even the steeper slopes of the type. The general farm crops of the area are grown, but the yields are not large. Corn yields from 20 to 40 bushels per acre, wheat from 7 to 15 bushels, oats from 20 to 45 bushels, and potatoes from 50 to 150 bushels. Apples do very well when the orchards are properly cared for.

The type is cultivated usually only where sheep are not kept to any extent. After a few years of cropping and exposure to rains the humus content of the soil becomes exhausted and then erosion becomes more rapid. Some have attempted to restore the loss of productivity by means of commercial fertilizers, with the result that a temporary increase in yields is noticeable, but the fields become washed and eroded more and more and finally have to be abandoned. It is believed that this type should not be used for general agricultural purposes but should be used exclusively for grazing and orcharding. It is thought that vineyards would do well. A farm composed entirely of this type would not be esteemed very highly, because there would not be an opportunity to grow general farm crops, but a considerable proportion

of a farm may be composed of land of this character without being considered detrimental, since it furnishes permanent pasture and may be used for orcharding in some instances.

Rough Stony Land.

The areas of rough stony land occur principally in the hills bordering the Ohio river and its larger tributaries. The larger streams as they approach the river have worn their valleys so deeply that the hills adjoining them, like those along the Ohio, are often abrupt and precipitous. These steep, cliff like hills are the ones which make up the type, rough stony land, and they are nearly always associated with hard, massive sandstone strata, which have been more resistant to the agencies of weathering and erosion than the more numerous strata of softer sandstones, shales, limestones, and coal lying above and below them.

In the northern part of the area the Lower Freeport sandstone is the one which gives rise to the type, while farther to the south the Buffalo, Saltzburg, and Connellsville sandstones have the greatest influence in its formation. These sandstones vary in thickness from 20 to 100 feet and are sometimes found high up in the hills and sometimes, owing to a uniform dip to the southeast, much lower down. At the higher elevations they sometimes form bare rock walls below which are strewn large angular bowlders of sandstone. Usually, however, the surface is very steep and strewn with sandstone fragments and covered with a thin layer of soil. The fine earth on these steep slopes is usually the product of the weathering of softer layers of sandstone and shale which underlie the massive sandstone, hence considerable clay is occasionally found. The original forest growth consisted largely of oak, maple, and hickory. This has all been removed and has been replaced by a small second growth. Immediately adjoining the stream courses small hemlocks are quite characteristic. Landslides which strip everything down to the underlying rocks are not uncommon in these steep slopes.

Rough stony land is really more of a condition than a soil type. It never has been and never will be of any great agricultural value, not being desirable even as grazing land. It is recommended that these slopes be allowed to stand in timber, which when it becomes large enough should be removed by systematic

forestry. The percentage of the area occupied by this type is so small that it has very little influence upon the agricultural conditions and value of lands in the region.

Dekalb Sandy Loam.

The soil of the Dekalb sandy loam is a medium-textured sandy loam of light-brown color and an average depth of about 10 inches. The subsoil, to a depth of three feet or more, is practically the same as the soil, except that it is somewhat lighter colored and sometimes has a slightly greater clay content. When the soil is dry it is rather incoherent. Very often there are considerable quantities of micaceous sandstone fragments varying from one-eighth of an inch to two inches in diameter scattered upon the surface and disseminated through both soil and subsoil. This is a residual soil derived principally from the weathering of the Pittsburg and Connellsville sandstones.

The Dekalb sandy loam is a very easy soil to handle. In the spring it can be plowed the earliest of any type in the area. It is, however, inclined to be quite droughty during the dry spells of summer, as the type occurs principally upon the hilltops and narrow winding ridges, and its natural drainage is apt to be excessive.

The native vegetation, which was largely chestnut, has been removed and all the type has at some time been in cultivation. At present about one-half of it is in pasture and the remainder used for general farm crops. Corn yields from 20 to 40 bushels per acre, oats from 20 to 45 bushels, and wheat from 8 to 18 bushels. When seeded down to timothy and clover the results are not satisfactory. The clover stand is poor and the timothy comes up thin and after the second year is crowded out by plantain and sorrel. Kentucky blue grass, the natural grass of the region, does not replace the timothy and clover. Owing to the rather loose, open nature of the subsoil the type has a tendency to leach and the effects of manure and other fertilizers are not lasting. A few farmers have used commercial fertilizers upon the type, but they report that the effects are not permanent enough to pay for the outlay.

The cultural methods at present used upon the Dekalb sandy loam are the same as upon the Dekalb silt loam and the Wheeling

clay loam. The type is so limited that not much of it is ever found upon any one farm, and the value of the lands and the general agricultural conditions in the area are not much influenced by the type. It is believed that the usual location of this soil upon hilltops and ridges and the texture of its soil and subsoil make it the best type in the area for peaches, and that orcharding would be more profitable upon it than general farming. On one farm a short distance north of Hollidays Cove alfalfa was growing, but the result was not very encouraging.

The following table gives the results of mechanical analyses of samples of the fine earth of this type:

Mechanical Analyses of Dekalb Sandy Loam.

Number	Description	Fine gravel	Coarse Sand	Medium Sand	Fine Sand	Very fine Sand	Silt	Clay
		Per ct	Per ct.	Per ct.	Per ct.	Per ct	Per ct.	Per ct.
15225, 15227....	Soil.......	1.1	10.3	19.9	16.1	10.3	25.4	15.9
15226..........	Subsoil....	1.5	11.9	18.7	17.6	4.2	34.9	10.8

Brooke Clay Loam.

The soil of the Brooke clay loam is a brown or dark-brown heavy loam or clay loam ranging in depth from 6 to 10 inches, with an average of about 8 inches. The subsoil is a light-brown clay and changes gradually to a slightly yellowish heavier clay at a depth of about 20 inches. Below this to a depth of 3 feet or more the texture remains a heavy clay, but the color continues to get lighter and sometimes at a depth of 3 or 4 feet it becomes a gray or drab. Scattered over the fields and disseminated through both soil and subsoil are small fragments of gray or bluish colored limestone and limy shale, and these rocks can often be seen outcropping in the road cuts. On narrow ridges where the surface soil has been removed by erosion the rock fragments are more noticeable and the surface material is apt to be a clay. This type requires very careful and intelligent treatment. If plowed when either too wet or too dry serious results follow. When plowed at just the right condition of moisture it turns easily and pulverizes readily, and is usually cultivated without difficulty.

It is believed that less trouble is experienced in handling it if plowing were done in the fall, so as to give the soil the beneficial pulverizing action of the frost during the winter months.

The type first appears near the southern boundary of Hancock county, on the hilltops southeast of Hollidays Cove, and is found from there to the southern boundary of the area. In its first appearance it occurs merely as caps for the highest hills, while farther south, where the formation from which it is derived becomes thicker, it occupies both the highest hilltops and ridges and extends down the hill slopes for a considerable distance. It reaches its best development upon the McCulloch's Ridge northeast of Wheeling. Farther south, as for example, along Wheeling creek, the formation from which it is derived passes under heavy cover and the type occurs as far down as the lower slopes of the hills bordering the creek.

The Brooke clay loam is derived from the disintegration of the limestone rocks and calcareous shales. Where the limestone areas are well developed and the stream courses have not cut down through the Monongahela series into the sandstone and sandy shales of the underlying Conemaugh series the topography is gently rolling to moderately hilly, with very little or no waste land along the stream slopes. The drainage of the type is very good, though not excessive. The soil absorbs moisture readily and retains it well during the dry spells in summer. The ability of the type to absorb and retain moisture causes the blue grass pastures to be much more permanent than upon the soils of sandstone origin, and this fact accounts for the greater profitableness of sheep raising.

The earliest settlements were made upon this type and the original growth of hardwood has all been removed. Fully 70 per cent of the type is at present under cultivation. It is recognized as the strongest and best soil in the area for general farm crops, and is easily kept in a good state of productiveness. Corn, oats, wheat, timothy and clover, and blue grass are the principal crops. Apples, cherries, plums, raspberries, strawberries, and garden vegetables are grown for home use and to some extent for market. Corn yields from 40 to 70 bushels per acre, oats from 30 to 60 bushels, and wheat from 15 to 35 bushels. Clover usually makes an excellent stand and is followed by timothy, which is cut for two or three years and yields about 1 or 1½ tons per acre. Blue

grass comes in as the timothy thins out and is very valuable for grazing purposes. Very few potatoes are grown upon this type, as it is considered too heavy.

Among the best farmers the type is handled very intelligently and with profit, and not many suggestions for improvements can be made. All of the farmers keep stock enough to maintain the productivity of the soil. Near the towns, however, there are a few farmers on this type who sell off all the available hay and straw and keep very little or no stock. Their farms have become "worn out," and it is recommended that stock be kept for dairy purposes and all of the hay and straw converted into manure and used on the farm.

The farmers have not felt the necessity of using commercial fertilizers upon this type. A few have used them, but without permanent beneficial results. The farmers as a rule feel that there is no fertilizer equal to barnyard manure, and when applied the beneficial effects are noticeable for years afterwards. A very few farmers have used a light application of lime, which seems to improve the clover crop and also seems to make it easier to put the soil in proper tilth.

The general agricultural conditions are influenced more by this type than any other in the area, and it is this type that has contributed most to the reputation of the region for producing a fine wool of long staple.

The following table gives the results of mechanical analyses of typical samples of the fine earth of this soil:

Mechanical Analyses of Brooke Clay Loam.

Number	Description	Fine Gravel	Coarse Sand	Medium Sand	Fine sand	Very fine sand	Silt	Clay
		Per ct	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
15245, 15247....	Soil.......	0.2	1.0	0.8	2.7	4.6	56.4	34.0
15246, 15248....	Subsoil....	.3	1.1	.7	2.5	3.8	48.0	42.8

Dekalb Silt Loam.

The soil of the Dekalb silt loam consists of a rather light brown mellow silt loam which varies in depth from 7 to 10 inches, with an average of about 8 inches. The subsoil to a depth of 3 feet of more is either a very light brown or a pale yellowish material varying in texture from a silty loam to a silty clay loam.

The type is quite similar in texture to the soil of the Steep broken land found lower down the slopes, but owing to its position and the smaller percentage of rock fragments found in both soil and subsoil and upon the surface it is a much easier soil to plow and cultivate than the latter, and therefore much better adapted to general agricultural purposes. Disseminated through both soil and subsoil and scattered upon the surface are sometimes found small fragments of sandstone and sandy shale, but these are never numerous enough to interfere with cultivation.

The type is well developed in Hancock county and in the northern part of Brooke county in connection with the sandstones and sandy shales of the Allegheny and Conemaugh series. It is also found less well developed southward over the remainder of the area in connection with the sandstone and sandy shale strata of the Monongahela and Dunkard series. This is a residual soil derived from the weathering of the sandstones and sandy shales of the rock series just mentioned.

The type occurs principally as flat or gently rolling tops of hills and ridges. The size and shape of the areas are variable, depending upon the extent to which erosion has eaten back into the old plateau. Occasionally erosion has reduced the ridges to a "hog-back," and in that case the Steep broken land extends over the ridge.

The Dekalb silt loam is sometimes found 100 feet or more below the tops of the hills, in a shelf-like position. This is due to the outcropping and weathering of resistant massive sandstone strata which extend around the contour of the hills, usually approximately parallel to one another. In a few cases the type is also found in the sandstone valleys, where it occupies the gentle lower slopes of the hills. Owing to the topography of the type and the texture of both soil and subsoil the drainage is good. Though not subject to severe washing or erosion it is more apt to suffer from a lack than from an excess of moisture.

The original forest growth of chestnut and oak has long since been removed and it is estimated that fully 80 per cent of the type is under cultivation. It is not especially well adapted to any one crop, but where carefully handled is a fair soil for the general farm crops of the area. Corn yields from 25 to 60 bushels per acre, oats from 20 to 50 bushels, wheat from 10 to 25 bushels,

and potatoes from 50 to 150 bushels. Apples, cherries, plums, berries, and garden vegetables do well and are grown for home use. Strawberries and raspberries also do well and are grown on a small scale for market.

In the early settlement of the region the type was not so rapidly taken up and cleared as was the limestone soil near by. This was due in part to the isolation of the areas and in part to the general recognition of the fact that soil of sandstone origin is usually less productive than one of limestone origin. Sheep raising never became very popular upon the Dekalb silt loam for the reason that blue grass did not thrive on this soil.

This is not naturally a strong soil type and can not be expected to stand the same methods of cropping as the Brooke clay loam, though this is what the farmers have been doing. The use of lime is recommended and the incorporation of more organic matter would prove beneficial. For this reason less hay or straw should be sold and enough stock should be kept to convert these into manure. In this way the type should be brought to a satisfactory state of productivity. Nearly one-half of the tillable farm lands of the area are composed of this type, so that it has a great influence upon the general agricultural conditions and value of farm property.

The following table gives the average results of mechanical analyses of the fine earth of the soil and subsoil of this type:

Mechanical Analyses of Dekalb Silt Loam.

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct	Per ct.	Per ct.
15229...........	Soil.......	0.0	0.7	0.5	1.6	17.9	63.0	15.9
15230..........	Subsoil....	.1	1.3	.4	1.6	30.2	46.1	20.2

Upshur Clay.

The Upshur clay consists of about 7 inches of red or dark red, stiff, tenacious clay, underlain to a depth of 3 feet by a red clay of a slightly heavier texture.

This is a very difficult type to till because of its stiff, tenacious character. It is spoken of locally as "cold, wet, late land," owing to the difficulty of plowing it in time for planting. In dry weather it has a tendency to bake and is very difficult to handle.

In wet weather it forms a deep, sticky mud in the roads, through which wagons pass with the greatest difficulty, and in dry weather these roads become very hard and rutty if not smoothed over with a road machine.

The Upshur clay is found in small unimportant areas in the northern end of the survey. It usually occupies the tops and slopes of small hills, and sometimes occurs as a band of soil extending around the hill, the rocks from which it is derived apparently extending through the hill horizontally. Occasionally it occupies the narrow ridges.

The surface of the Upshur clay is usually steep and hilly, and where the soil occurs on the hillsides it has a tendency to gully and wash badly, the impervious nature of the soil preventing the absorption of the rain.

The Upshur clay is a residual type derived principally from the weathering of the soft, marly, red shales of the Pittsburg formation. In the region where the Upshur clay is mapped these shales occur well up toward the tops of the highest hills, where they have a chance to weather into soil. The same shales were seen in many places along road cuts and stream courses farther south, but owing to the steepness of the slopes they have no soil covering. The red color of this type is not due to recent oxidation, but to the deposit of red sediment derived from the erosion of old land areas when the Conemaugh series was being deposited. The soil usually contains fragments of limestone and iron ore.

The native vegetation consisted of hard woods, principally oak, hickory, beech, and maple. Practically all the type has been cleared and put under cultivation, but, owing to the great difficulty of handling it is not a satisfactory soil for general farming and is used mostly for hay and pasture. It is well adapted to these purposes, and when carefully handled is a fairly good soil for wheat and corn. Wheat yields from 10 to 20 bushels, and corn from 20 to 50 bushels per acre. Not many oats are grown upon the type and it is not well adapted to potatoes or fruits.

When wet this soil is not porous enough to allow water to pass downward readily, so it becomes water-logged and lacking in aeration. In times of drought it bakes and becomes difficult to till. The type needs a treatment which will overcome these tendencies. A heavy application of lime is recommended, and the

plowing under of clover or other coarse organic substances would also be very beneficial.

Owing to the small percentage of the area occupied by this type it has but little influence upon the general agricultural conditions and value of lands in the region. The red clay has considerable value for making earthenware and is used for this purpose in a number of potteries.

The following table gives the results of six mechanical analyses of the soil and subsoil of this type:

Mechanical Analyses of Upshur Clay.

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per ct.	Per ct	Per ct	Per ct	Per ct.	Per ct.	Per ct
15217..........	Soil.......	0.1	0.9	0.8	2.7	8.4	33.0	54.4
15218..........	Subsoil....	.8	3.1	2.0	6.2	10.1	29.3	48.9

Huntington Fine Sandy Loam.

The soil of the Huntington fine sandy loam is a fine sandy loam varying in color from light brown to dark brown or nearly black. The subsoil to a depth of 36 inches or more is about the same in texture as the soil, but is lighter in color, though in places it seems to contain considerable organic matter. The presence of a considerable portion of the organic matter in both soil and subsoil is accounted for by the fact that small fragments of limbs, bark, leaves, and other debris were deposited with the fine sand. The soil is an easy one to plow and cultivate, being mellow and having little tendency to pack or bake. The elevation of the type above the normal level of the river is from 20 to 40 feet, and consequently a large proportion of it is under water every spring, and sometimes later in the year. It occurs as long, narrow strips bordering the banks of the Ohio river, and is sedimentary in origin, being still in the process of formation. Often the long, narrow strips are somewhat higher than the area back of them, presenting the appearance of a natural levee. This is accounted for by the fact that when the river overflows its banks, the heaviest and greater part of the material is deposited as soon as the current slackens in overflowing the banks.

None of the hardwood timber which originally covered this type is now standing, the land being in great demand both for general farming and for trucking. Of the general farm crops, corn does well, the average yield per acre being about 45 to 50 bushels. Only fair yields of wheat and oats are obtained. Hay will yield on an average from three-fourths to one ton per acre. It is an excellent type for Irish potatoes, the average yield being about 150 bushels of salable potatoes per acre. Cabbage will yield about 300 barrels per acre. Besides these general and special crops, asparagus, tomatoes, onions, radishes, lettuce, and grapes are also produced. Some small fruits and berries are grown for the near-by markets.

Although of limited extent, the Huntington fine sandy loam has considerable influence upon the agricultural conditions and value of land within the area, because of its especial adaptability to commercial trucking, and its convenience to markets. The fertilizer problem is simplified by the nearness of the type to numerous livery stables, where manure can be obtained cheaply, and by the level roads over which to haul it.

It is recognized that this type is well adapted to general farm crops, but because of its especial adaptability to truck, convenience to market, and the inability of the area to satisfy the demand for the latter products, it is believed that it would be more profitable to grow truck crops exclusively.

The following table gives the results of mechanical analyses of samples of this type:

Mechanical Analyses of Huntington Fine Sandy Loam.

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
15239	Soil	0.5	1.6	1.0	13.3	38.7	32.2	12.4
15240	Subsoil	.0	.2	.4	14.0	45.8	27.5	12.8

Dekalb Loam.

The soil of the Dekalb loam is a light-brown loam from 7 to 12 inches deep, with an average depth of about 8 inches. The subsoil, to a depth of about 24 inches, is a pale-yellow clay loam,

which frequently has a slightly greasy feel when rubbed between the fingers. Below 24 inches the material is heavier in texture, and is often mottled with gray or drab. At a depth of 5 or 6 feet, as shown in the road cuts, the subsoil rests upon a mass of disintegrated sandstone, beneath which occurs the bed rock. Scattered upon the surface and disseminated through the soil and subsoil are often found small fragments of sandstone, but these are not numerous enough to interfere with cultivation. On the tops of some of the narrow ridges where the bed rock comes closer to the surface and the small sandstone fragments are more numerous, the soil is somewhat sandier than the average.

The Dekalb loam is not as difficult to farm as the Brooke clay loam, but is heavy enough to demand care and attention in plowing and cultivating. When properly handled, there is no trouble from puddling or baking.

The Dekalb loam is confined to the uplands of the southern part of the area, and is especially well developed in the region south and southeast of West Liberty, extending to the southern boundary of the area. In the vicinity of West Liberty it occurs as a capping for the highest hills, but the areas become larger and better developed to the south, as the formation from which it is derived becomes thicker.

The topography varies from broad and gently rolling to hilly and sometimes deeply eroded areas. The drainage, as a whole, is excellent, but in places where the surface is nearly level artificial drainage would be beneficial. In such places iron concretions are often present in the subsoil. In dry weather the crops are not apt to suffer from drought, except upon the narrow ridges and hilltops, where the underlying bed rock comes close to the surface.

The Dekalb loam is a residual soil derived from the weathering of fine-grained sandstone and sandy shales. The native vegetation was largely chestnut, with considerable oak, beech, and maple. The type is not especially well adapted to any one crop, but is a fair soil for the general farm crops of the region. Corn yields from 25 to 60 bushels per acre, with an average of about 40 bushels; oats from 25 to 50 bushels, with an average of about 35; wheat from 8 to 25 bushels, with an average of about 15, and hay from three-fourths of a ton to one and one-half tons, with an average of about one ton. Potatoes, vegetables, and small fruits do remarkably well, but are usually grown only in small

patches for home use. During the last decade considerable difficulty has been experienced with the clover crop. It seems to die out in spots the first year after sowing, and is replaced by plantain and sorrel. The trouble seems to be greatest where commercial fertilizers have been used to the exclusion of barnyard manure. Very few farmers have used lime on the fields thus affected, but those who have done so are satisfied that the results more than justify the expense. At present but little commercial fertilizer is purchased, but the value of barnyard manure is well understood by the farmers, many of whom haul it from the city. Few sheep are kept, but near Wheeling and along the trolley lines leading to that city dairies are numerous. These dairy farms are the most productive found on this type, due solely to better management and the use of stable manure.

On the hills near Wheeling, where stable manure can be hauled from the city, some truck crops and fruit are grown successfully, but the area used in this way is very limited. Heavy annual applications of manure are necessary where truck crops are grown year after year without regard to rotation. When the manure can not be secured the land is seeded down to grass and allowed to recuperate for a few years.

The Dekalb loam is a somewhat stronger soil than the Dekalb silt loam, and is considered the more valuable by the farmers. The reported yields are slightly in excess of those on the Dekalb silt loam. About 13 per cent of the upland portion of the area is occupied by this type of soil.

The following table gives the results of mechanical analyses of samples of this type:

Mechanical Analyses of Dekalb Loam.

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct	Per ct.	Per ct.
15221, 15223....	Soil.......	0.9	2.5	1.3	2.5	9.2	58.8	24.5
15222, 15224....	Subsoil....	.9	3.3	1.3	2.1	3.2	51.9	37.3

Wheeling Gravelly Loam.

The soil of the Wheeling gravelly loam has an average depth of about 8 inches and consists of a brown loam usually con-

taining considerable coarse sand and fine gravel. Local variations occur, in which the soil may contain considerable more than the average quantity of silt, or again the sand content may be rather high, so that we find the interstitial material in phases ranging from a silty loam to a heavy sandy loam. The subsoil to a depth of 3 feet or more is a light brown or yellowish gravelly loam. The particles of gravel vary from one-fourth to two or more inches in diameter and consist largely of waterworn shale and rounded fragments of the harder rocks. Occasionally the surface is strewn with rounded stones and gravel, but they are seldom numerous enough to interfere with cultivation. On the whole, the type is a loose porous soil, easily handled, and never too steep for cultivation.

The Wheeling gravelly loam is confined principally to the terraces of the Ohio river and occurs as long, narrow strips whose elevation above the normal level of the river varies from 40 to 100 feet. Its topography varies from nearly level to rolling and hilly. The loose open nature of the subsoil insures good natural drainage and where the surface is hilly the drainage may be excessive, so that crops are apt to suffer severely during dry weather.

The Wheeling gravelly loam consists of reworked material brought from the glacial region to the north when the volume of the river was greater than now. The sand, gravel, and stones found beneath the surface represent approximately the original condition of deposition. The surface of the type, however, has been more or less modified by weathering and an accumulation of organic matter since the deposition of the type, producing a fair soil for agricultural purposes. It was originally forested with the hardwood trees common to the region, but none of these are now standing and the type is used either for orcharding or general farm crops.

The type is better adapted to corn than to any of the other general crops, the yields averaging about 45 bushels per acre. The wheat yields average about 15 bushels, but range from 10 to 25 bushels. Oats range from 25 to 50 bushels, with an average of about 35 bushels. The yields of hay are usually not more than one ton per acre on an average. Truck crops are grown to some extent, and judging from what was seen in this area and what has been done upon the same type of soil in other areas it is evi-

dent that the trucking industry should be extended. Potatoes can easily be made to yield on an average 125 bushels per acre. Some very good apple orchards are growing upon this type and it is believed that an extension of this industry would prove profitable. Plums, cherries, and pears also do well. The same type in other areas produces good tobacco. Barnyard manure is practically the only fertilizer used upon the type.

The Wheeling gravelly loam is not an extensive type of soil in the Wheeling area, but its convenience to the markets and the possibilities of extending the trucking and fruit industry make it a much more important type than is at present thought, and it might be made to affect the agricultural conditions and value of lands within the area more than it does at present.

The following table gives the results of mechanical analyses of samples of this type:

Mechanical Analyses of Wheeling Gravelly Loam.

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
15241, 15243....	Soil.......	0.2	5.1	12.8	15.7	19.6	30.3	15.7
15242, 15244....	Subsoil....	4.8	11.7	6.3	15.6	25.0	18.9	18.0

Wheeling Sandy Loam.

The Wheeling sandy loam consists of about 8 inches of light-brown sandy loam, resting upon a rather incoherent yellowish sandy loam or sand, which extends to a depth of 3 feet or more. Scattered upon the surface and disseminated through soil and subsoil are sometimes found numerous quartz pebbles. Owing to the loose, loamy nature of the soil and its good under drainage the type is an easy one to cultivate.

The Wheeling sandy loam is confined to the terraces of the Ohio river, where it usually occurs only in small patches. The only place where the areas were large enough to map was at Arroyo, in the northern part of the area. Here it occurs as a gently rolling terrace and has excellent surface and under drainage. The elevation of the terrace above the river is about 40 feet.

This type is composed of reworked material brought from the glacial region to the north when the volume of the river was much greater than now, and the sand of the subsoil represents approximately the original condition of the material at deposition. Since it was laid down, the surface material has been somewhat modified by the accumulation of organic matter. The type was originally forested with the hardwoods of the region, but is at present cleared, the type being in great demand for the production of apples. The growing of apples upon a commercial scale began upon this type and from these areas as a nucleus it has spread out over the tops and sides of the hills roundabout. The character of the type and the climatic conditions in the Ohio Valley make the Wheeling sandy loam especially well fitted to the production of the Willow Twig, the Northern Spy, and the Rome Beauty varieties of apples, and a few skilled orchardists have become wealthy in the business. The greatest enemy to the orchards is the codling moth, and spraying is a necessity. The common practice is not to have the gound in sod for more than a year or so at a time, and when the orchards are pastured hogs and sheep are preferred to cattle because the last are more likely to injure the trees. Cowpeas and rye are used extensively as cover crops, the peas being sown in June and the rye in September.

Practically the whole of the type is in orchards, hence little can be said as to its adaptability for other purposes, except as this has been determined in soil surveys in other States. In some of the other States it is a typical trucking soil and in other places it is used very successfully for grapes, corn, potatoes, peaches, and small fruits.

The following table gives the results of mechanical analyses of samples of this type:

Mechanical Analyses of Wheeling Sandy Loam.

Number	Desription	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per ct.	Per ct.	Per ct	Per ct.	Per ct.	Per ct	Per ct.
15237...........	Soil.......	0.2	10.4	22.9	31.3	7.8	16.8	10.6
15238...........	Subsoil....	.3	5.8	26.7	30.7	10.3	17.3	9.5

Huntington Loam.

The Huntington loam is a light brown or brown loam with an average depth of about 10 inches, resting on a subsoil of a light brown or yellowish loam usually somewhat heavier than the soil and extending to a depth of 30 inches or more. The color of the soil and subsoil is somewhat variable. Along Wheeling creek, where the limestone material has entered into the formation of the type, the soil is dark brown and in places almost black. In locations where the drainage conditions are poor the subsoil is apt to be drab colored. The texture of the type also varies, often within short distances. Sometimes the soil in patches contains decidedly more fine sand and occasionally some gravel, and in the lower depth of the subsoil it is not uncommon to encounter considerable gravel.

The Huntington loam occurs as first bottoms along the Ohio river and its larger tributaries. Its usual topography is level or slightly rolling. It is each year subject to several overflows during the spring months, but there is little danger from these after planting time and during the growing season. The surface drainage and under drainage are usually fair, owing to the slight fall toward the near-by streams and the presence of gravel in the lower depths of the subsoil. Only a few depressions were seen where artificial under drainage would be beneficial.

The Huntington loam consists of a mantle of recent alluvial material spread out over the gravel deposits of the Glacial period. In places the wash from the adjoining hills is contributing to its formation, and in general it is still in progress of building, as each overflow leaves a thin deposit of loam and organic matter washed from the upland soils.

None of the original hardwood timber is now standing. In the early days the type was in great demand as a general farming soil, being regarded as especially well adapted to corn. The present average yield of corn, when well cared for, is about 60 bushels per acre. Other general farm crops are grown to some extent and with fair yields. Of late years the trucking industry has assumed considerable importance upon the type, owing largely to its especial adaptability to that purpose and also to the convenience to market and the increasing demand for trucking products. All of the ordinary truck crops of the region are grown with profit.

The following table gives the results of mechanical analyses of samples of this type:

Mechanical Analyses of Huntington Loam.

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct	Per ct.	Per ct.
15219...........	Soil.......	0.0	0.4	0.2	2.6	25.7	44.4	25.9
15220...........	Subsoil....	.1	.1	.1	2.2	24.2	44.9	27.6

SUMMARY.

The Wheeling area is located in the northern end of the Pan Handle of West Virginia and includes all of Hancock, Brooke, and Ohio counties and part of Marshall county. In a north-and-south direction it is 45 miles long, while in an east-and-west direction it varies in width from 4½ to 12 miles. It contains 201,600 acres, or 315 square miles. The Ohio river borders the area on the western side and for a mile or so back from the river the region is very hilly and dissected, but farther back it becomes less abrupt and broken and is better suited to general farming. The floors of the valleys are seldom wide enough to permit the accumulation of sediment along the streams, for which reason there is little bottom land in the area. The steep vertical erosion adjacent to the Ohio river and the absence of bottom lands over a large part of the area have rendered much of it unfit for general farming, but this is partly compensated for by the fact that beds of coal and fire clay are exposed.

The present farming population, which is about 30 per cent of the total population of the area, are mostly the descendants of the settlers who came from Virginia, Maryland, and North Carolina. The remaining 70 per cent of the population live in the towns and represent people from various States and foreign countries. The town people are largely a laboring class employed in various industries, and they furnish a greater demand for all kinds of products than is at present being supplied by the agricultural population of the area.

The farms are not being worked to their full capacity, largely because of the scarcity and high wages of skilled farm

labor. The output of the farms is mostly limited by what the owner can do himself. An abundance of modern farm machinery and good work stock are used, and the farmers as a class are wide-awake and are making a good living. Since the sale of their coal, oil, and gas rights, however, some of them are neglecting their farms.

The Brooke clay loam is the most important soil of the area for general farm crops and is the type which has made the region famous for sheep, yielding a fine wool of long staple. The Dekalb loam is an important soil for the same products. Both of these soil types are also well adapted to fruit and truck crops. The Dekalb silt loam, though not so well adapted to general farming and stock raising as the types first named, is somewhat better adapted to fruit and truck crops. The Dekalb sandy loam, though limited in extent, should be an important type for fruit and trucking purposes, and judging from the experience of one farmer it seems that alfalfa would be profitable. The Upshur clay had better be used exclusively for meadow and pasture. The remaining upland types, which are too steep for convenient tillage, are very important for pasture, and, as has been demonstrated in Hancock county, are also very important for commercial orcharding. The level sedimentary and alluvial types found along the Ohio river and Short, Cross and Wheeling creeks are very well adapted to all kinds of trucking purposes, and where general farming is pursued upon them it is recommended that it be discontinued, as they are too valuable for trucking purposes to be used for general farm crops.

The question of maintaining the productiveness of the sedimentary and alluvial types is easily solved, both by reason of the frequent overflows and because of the nearness to cities, where stable manure may be obtained cheaply, but upon the upland types the problem is considerably more serious. Any system of general farming upon the uplands, which excludes stock raising, must ultimately prove a failure and it is recommended that more stock be kept to supply the increasing demands for dairy products and mutton, and indirectly to furnish the needed organic manures.

APPENDIX.

LEVELS ABOVE MEAN TIDE IN THE PAN HANDLE AREA.

Baltimore and Ohio Railroad.

(Elevation to top of rail.)

Benwood	650
Wheeling	647
Mont de Chantal	672
Elm Grove	667
Roneys Point	829
Point Mills	896
West Alexander (Pa.)	1043

Pennsylvania Railroad—Pittsburg, Wheeling, and Kentucky Division.

(Base of rail, given by Thomas Rodd, Chief Engineer).

Wheeling	645
Wellsburg	660.6
Cross Creek	669
Follansbee	672.5
Lower Ferry	671
Middle Ferry	694
Steubenville (Ohio)	728
Wheeling Junction	714
Kings Creek	669.56
Black Horse	666.56
New Cumberland	666.56
Globe	671
Congo	686.16
Chester	704.16

Pennsylvania Railroad, Main Line.

Hollidays Cove	720.3
Colliers (town) 400 feet west of the station	800
Colliers Station	823.92

Wabash Railroad.

(Elevation, top of rail, H. T. Douglas, Jr., Chief Engineer).

West abutment bridge at Rockdale	708.5
Top back wall right hand side east abutment, first bridge east of State line tunnel	807.28
Top rail at Pennsylvania-West Virginia State line	794.46

ELEVATIONS ABOVE TIDE IN THE PAN HANDLE COUNTIES DETERMINED BY THE U. S. GEOLOGICAL SURVEY.

The following elevations of the U. S. Geological Survey determined and marked in Ohio, Brooke, and Hancock counties, are taken from volume I-a (pp. 574-578) of the West Virginia Geological Survey. Dr. I. C. White's remarks on the value of these levels are also included:

"The topographic branch of the U. S. G. Survey, in connection with and aided by the U. S. Coast and Geodetic Survey, is covering the entire United States with a net work of precise elevations. As the result of precise leveling, many of the old levels and bench marks accepted for many years as accurate by the railroad officials, civil engineers, and others, have been proven erroneous, often to the extent of several feet. In this readjustment of elevations the U. S. G. Survey finds it necessary to change slightly, as a higher degree of accuracy is attained, some of its own former standard elevations, and thus those given of the same bench mark for one year may differ slightly from those given in a later publication. The railroad, civil and mining engineers, are now almost universally adjusting their levels to those given by the U. S. G. Survey, especially since the recent plan has been adopted of placing bronze tablets marked with the elevations in conspicuous positions every few miles in each quadrangle surveyed."

Hancock and Brooke Counties.

Wellsburg and Steubenville Quadrangles.

The elevations in the following list are based upon an aluminum tablet at the southeast corner of the Jefferson county court house at Steubenville, Ohio, marked "716 STEUBENVILLE." The elevation of this is accepted as 714.729 feet above mean sea level and was determined from the Army Engineers' bench mark "67 A" on the water table of the same building, the elevation of which in accord with the Coast and Geodetic Survey adjustment of 1903 of precise leveling is 710.306 feet.

The initial points upon which this leveling depends include other bench marks of the Army engineers' precise level line along

the Ohio river, the elevations accepted for which accord with said adjustment.

The leveling on the Wellsville quadrangle was done in 1902 under the direction of Mr. Van H. Manning, topographer, by Mr. A. T. Bagley, levelman.

The leveling on the Steubenville quadrangle was done in 1902 under the direction of Mr. C. F. Cooke, topographer, by Mr. J. E. Buford, levelman.

All permanent bench marks dependent on this datum are marked with the letters "STEUBENVILLE" or "STBNVL," in addition to the figures of elevation.

East Liverpool, O., via Fairview, W. Va., to New Cumberland, W. Va.

Feet.

Chester, 1 mile south of; 0.25 miles east of Locust Grove Cemetery, Allison triangulation point, bronze tablet in top of marble post marked "1337 STBNVL"....................1337.156

Fairview, on the north side of Tri-State Normal School, at base of stone frame to front door of; aluminum tablet marked "1196 STBNVL"......................................1195.636

New Cumberland (U. S. A. Engineer Corps bench mark "56A"), D. S. Schiller Foundry Co.'s works, southwest corner of Iron and Ferry streets, in west end of door step, chiseled square 670.66

Cross Creek Bridge Northeast to Colliers, Thence West to Hollidays Cove.

Feet.

Cross Creek, 3rd bridge over, opposite Wabash concrete bridge, southeast corner of, in stone abutment, chiseled cross......672.400

Colliers Station, at northwest corner of bridge, in stone abutment of, aluminum tablet marked "824 STBNVL"..........823.597

Hollidays Cove, 0.5 miles east of; bridge marked "39" Panhandle railroad, in southeast corner, in coping stone, chiseled cross.741.90

Hollidays Cove Station North to New Cumberland.

Feet.

Zalia, 100 feet south of church, on east side of road, opposite lower end of Toronto street ferry, in big boulder, bronze tablet marked "704" STBNVL"..........................703.720

New Cumberland East to Carson's Oil Wells, Thence Southwest to Holidays Cove.

Feet.

New Cumberland, 3:25 miles east of; at northeast corner of bridge, "T" cut in stone.................................. 735.14

Comettsburg, southwest corner of Freshwater's house, bronze tablet marked "1150 STBNVL"..........................1149.920

Schoolhouse on Cross Creek via Independence, Pa., to Wellsburg, W. Va.

	Feet.
Colliersville, 5 miles south of; covered bridge, in southwest corner of abutment, cross cut in stone	754.58
Independence, Pa., 2.5 miles northwest of; bridge over creek, in southeast corner of, aluminum tablet marked "784 STBNVL"	784.024
Wellsburg, W. Va., 1 mile east of; stone horse block in front of Jacobs' house, aluminum tablet marked "1001 STBNVL"	1000.935

Brooke and Ohio Counties.

Wheeling Quadrangle.

"The elevations in the following list are based upon Coast and Geodetic Survey bench mark "M" at Grafton, W. Va., a chiselled square on the top of the north side of the central pier of the Baltimore & Ohio railroad bridge over Tygarts Valley creek. The elevation of this as determined by the bureau by the adjustment of 1903 precise leveling is 996.856 feet above mean sea level.

"The initial points upon which these levels depend are various bench marks of the Army engineers' (Ohio River Survey) and Coast and Geodetic Survey (transcontinental) precise level lines of the precise level net. The leveling on the Wheeling quadrangle was done in 1901 under the direction of Mr. W. C. Hall, topographer, by Mr. W. A. Freret, Jr., levelman. All permanent bench marks dependent on this datum are marked with the letters "GRAFTON" in addition to the figures of elevation."

Wheeling Along National Pike via Elm Grove to Triadelphia.

	Feet.
Wheeling, city building north front of; 37 feet east of northwest corner of (U. S. Engineer Corps' bench mark), No. 90 "A," chiseled square	678.250
Wheeling, 1.1 miles east of postoffice, Baker street bridge on Wheeling creek, southeast end of bridge, on southwest corner of coping stone, chisel mark	651.23
Elm Grove, 1 mile southeast of; bridge over Little Wheeling creek, near its junction with Big Wheeling creek, on top of west coping wall, in third stone from center, cut	694.75
Triadelphia, M. E. church, brick building, southwest corner of, in foundation stone, south face, aluminum tablet marked "743 Grafton"	744.570

Triadelphia Along Middle Wheeling Creek via Twilight to Valley Grove.

Feet.

Twilight, 1.1 miles northeast of; northeast abutment of bridge over Wagners run, northeast corner of stone, chisel mark..802.03

Twilight, 3.1 miles northeast of; near junction of Haneytown pike and Middle creek road; bridge over Little Wheeling creek, northeast retaining wall of, corner of fourth stone from top, chisel mark....................................949.79

Valley Grove, Baltimore & Ohio railroad bridge No. 174, (Pittsburg division), north face of south pile, bronze tablet marked "953 GRAFTON"..952.648

Valley Grove Along National Pike and McGraw's Run to Bethany.

Feet.

Bethany, 5.1 miles south of; 6.5 miles north of Valley Grove, southwest abutment wall of wooden bridge over Long run, on southeast corner of third stone from top, chisel mark...1020.87

Bethany, two miles south of, northeast corner of M. E. church, southeast front step, in top stone, chisel mark............ 954.32

Bethany, 0.3 miles west of; Bethany College, front face of building, first entrance west of main entrance, north side of entrance, east face stone, water table, aluminum tablet marked "932 GRAFTON, 1901"............................931.774

Bethany Along Pike to Short Creek.

Feet.

Bethany, 2.6 miles west of; west end of bridge over Buffalo creek, north wing wall, on northeast corner of; top stone, chisel mark..743.82

Shortcreek, brick store and postoffice, west face of, 25 feet from southwest corner and two feet above ground, aluminum tablet marked "668 GRAFTON, 1901"......................667.963

Shortcreek, 0.1 mile south of; west side of railroad track Pittsburg, Cincinnati, Chicago & St. Louis railroad bridge No. 12, over Shortcreek (division line between Brooke and Ohio counties, W. Va.), south abutment of, chiseled square on top of, marked "B M," U. S. Engineers' bench mark No. 81 A..652.724

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R.

S.

WHEELING NEWS LITHO. CO., WHEELING.

New Topographic Map of
Ohio, Brooke and Hancock Counties, West Virginia.

Since the exhaustion of the supply of the Detailed County Report on Ohio, Brooke and Hancock Counties with its accompanying atlas of maps, the Geological Survey has had many calls for Topographic and Geologic Maps of this important manufacturing area of West Virginia.

The Geological Survey is now prepared to supply copies of the Topographic Map of this area, the map being printed on one sheet and being on the scale of one mile to the inch. The cultural features have been brought up to date. All the roads, streams, towns, villages, schoolhouses, and much other data have been placed on this map. The State Roads with State Route Numbers and all Main County Roads are shown in red, and by-roads and trails, are shown in black.

Price of Topographic Map, 75 cents.

The Geologic Map of this area will be published within five or six months.